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TOBACCO:—BREEDING CIGAR FILLER IN OHIO

REPORT OF HYBRIDIZING AND SELECTION WORK IN THE MIAMI VALLEY DISTRICT, 1903-1911

BY A. D. SELBY AND TRUE HOUSER
IN COOPERATION WITH THE BUREAU OF PLANT INDUSTRY,
UNITED STATES DEPARTMENT OF AGRICULTURE

INTRODUCTION

The success of any form of crop production must depend upon the combined quantity and quality of the product; this, in turn, may be considered an index to the effectiveness of the plants which constitute the crop grown. The consideration of these matters of effectiveness of known varieties to produce the results demanded by the conditions at any given time suggest a vast number of questions pertaining to the origin, history and adaptation of the varieties under culture for that time.

Questions of this sort were raised when the tobacco growers of the Miami Valley presented their problem as to possible improvement in cigar filler tobacco in that district. Aside from whatever suggestions were made by the association of growers, the general question of filler improvement required that many phases be investigated. In other days the dominant consideration might have been to seek out and test other strains of tobacco from other parts of the world. While all of this is of interest, we have learned in our time that the more definite and effective method is to be found in applying the known laws of cross breeding, or hybridization. Even though this making of tobacco hybrids has not been followed in all its possible breadth of scope, enough has been done to show that

the method is applicable to present day conditions in Ohio. That the laws of plant breeding offer an unlimited field for their operation and almost unlimited possibilities in the modification of the plants and crop will appear even more clearly from the results given in the present bulletin. We conclude from the work already done that essentially proper methods have been followed and that very promising results have been obtained.

In a recent bulletin on tobacco growing in Ohio* the historical relations and present day conditions of tobacco culture have been presented. The preparation and publication of the matter contained in that bulletin properly preceded the present one on tobacco breeding, the two parts being originally designed to constitute a single bulletin. Readers are accordingly referred to the general bulletin for general matters, the discussions upon breeding being restricted to that phase of the subject in this bulletin.†

Previous to 1903 the Ohio Agricultural Experiment Station had not undertaken regular tobacco investigations, except in so far as these related to requests for services in dealing with diseases. During 1902 and the earlier part of 1903 the Germantown Tobacco Growers' Association was successful in securing the necessary legislative action providing for the Southwestern Test Farm at Germantown.‡ While this work was begun upon leased land, the legislature has recently appropriated the necessary funds for the purchase of the land previously under lease and option, thus insuring the permanence of the work.

Among other discussions by the tobacco growers in their association were those relating to the apparently diminished yields of the Zimmer Spanish variety so largely grown in that district. In view of the assertion that Zimmer Spanish is a hybrid resulting from a cross between Cuban and Connecticut Seedleaf, the growers formally requested that the Station undertake to make crosses between these named varieties, and such other hybrids and selections as might be of value for cigar filler purposes. The Station Botanist was requested to take up this work by the Director of the Station.

ASSUMED DETERIORATION OF ZIMMER SPANISH

The tobacco growers, and more especially those of the Germantown district, were free to assert at this time that the Zimmer Spanish variety had deteriorated. As evidence it was insisted that the yields obtained were lower than ten to fifteen years before, and the consequent returns to the grower inadequate and unsatisfactory.

* Bulletin Ohio Agricultural Experiment Station 238:263-359, March, 1912.
† Bulletin Ohio Agricultural Experiment Station 156:108-111, 1904.
‡ See Bulletins 161, 172 and 206.

The results of investigations conducted by the Department of Botany as to the effect of proper suckering and time of cutting of the crop upon the yield have failed to show the correctness of this view. See pages 308 to 314 of Bulletin 238. These experiments have, on the contrary, shown that the tobacco yields have diminished through the practice of careless methods, and more especially as the result of insufficient labor devoted to timely topping and suckering the crop. As the usual outcome of careless practices, both the quantity and quality of the crop have suffered a decline. From the standpoint of quantity the experiments of the Assistant Botanist have shown how necessary it is for tobacco to stand a reasonable length of time after topping, in order to realize the best returns from the crop. Summarized, these results show that tobacco cut six weeks after topping yielded 1,377 pounds per acre against 844 pounds per acre cut three weeks after topping, as is the usual custom, an increase of 63 percent at the slightly increased cost of proper suckering. It seems clear from this work, therefore, that Zimmer Spanish in the Miami Valley district will, under like conditions, yield as good returns in pounds per acre as were ever obtained from it. The same far-reaching effects of ill-timed and misguided effort are just as likely, or almost as likely, to apply to any other variety extensively grown in the district. Even moderate excellence in tobacco growing requires that the operations shall be performed at the proper time and in a workman-like manner.

THE PROBLEM STATED

The problem as stated by the tobacco growers in 1903 was that of need for more profitable and, if possible, more productive varieties for cigar filler purposes. That the assumed deterioration in Zimmer Spanish was not proved by subsequent facts in no way discredits the desire for improved strains of filler tobacco. In answering this call for service it has been the aim to consider the problem from every standpoint which promised improvement. It soon became clear from our selection work with Zimmer Spanish that no progress was made toward either a higher quality or a higher yield in this variety by selecting individual seed plants. Improvement seemed possible, therefore, only by the method of crossing followed by selection, which has been practiced throughout all of the work with hybrids. Early in these investigations, in order to test successfully the smoking qualities of the tobacco, the cooperation of the Office of Tobacco Investigations, Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C., was solicited and cordially given in the work. The detailed results of

this breeding work, designed to meet the need for better cigar filler tobaccos, are set forth in subsequent pages. After nine years of effort it would appear that decided progress has been made, and the results have, therefore, been brought together for publication. It will be noted that during the past three seasons seed of certain hybrids has been distributed to individual growers who have tested these in connection with their standard sorts.

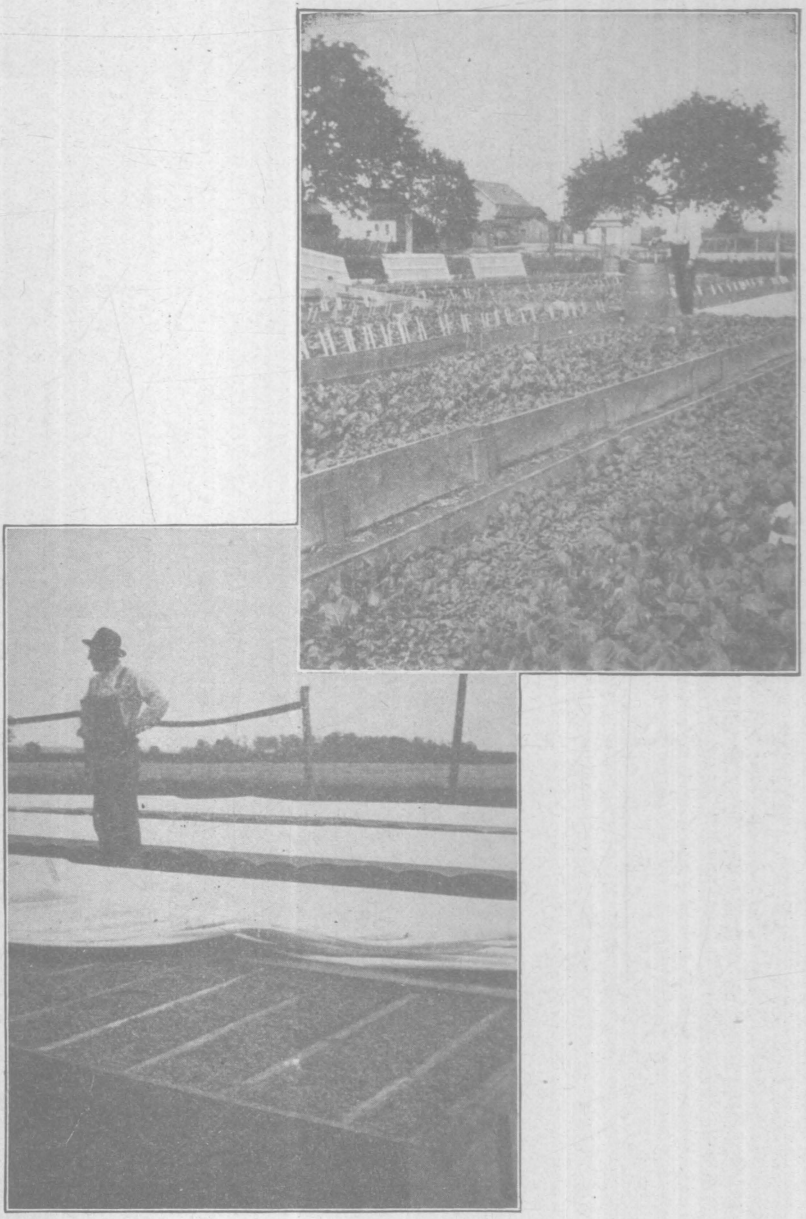
THE OBJECT OF CIGAR FILLER IMPROVEMENT IN OHIO

The object of the breeding work with cigar filler tobaccos herein reported is to increase the yield, to improve the quality, and to lower the cost of production per unit of value.

Yield. Under the conditions obtaining in the Miami Valley there is but little probability of being able to produce tobacco which will command sufficient price per pound to make its culture profitable without at least moderately good yields. While the necessity for good yields is obvious these should not be obtained at too great a sacrifice of quality nor call for too large an increase in the cost of production. In this connection it is a fortunate circumstance that high quality does not seem necessarily to be correlated with low yielding power.

Quality. The quality, especially the apparent quality as indicated by the color, finish and texture of the leaf in connection with its size and shape, has much to do with the selling price of the product. Hence, high quality is an important attribute to be sought in breeding for the improvement of cigar filler tobacco, but it must not be obtained at the expense of yield nor by too great an increase in the cost of production.

The cost of production. Not the cost of production per acre but the cost per dollar's worth of cured tobacco is the point in which the farmer is really most interested. No matter what the yields or quality, there can be no profit unless the product sells for more than it costs to produce it. It is plain that, other things being equal, the higher the yield per acre the less it will cost to produce one dollar's worth of the finished product, for the interest on money invested in land, buildings and machinery and the labor required to grow the tobacco are but slightly greater with large yields than where average or poor yields are obtained. Likewise, any improvement in quality, which does not result in decreased yield, usually lowers the cost of production when measured by the value of the crop, for quality costs but little in the way of increased care and labor.



1 2

Fig. 1. Showing plant beds at Germantown, Ohio, for growing small lots of many kinds of tobacco hybrids. In No. 1, the different kinds are separated by ordinary plastering laths laid across the beds after seeding, the sowing being made in bottomless board frame to protect from scattering seed. No. 2 shows painted garden stakes numbered in duplicate to be carried with each lot of plants for the duplicate row plantings in the field.

Aside from the yield and quality certain other characters of the tobacco plant are related to the cost of production, such as promptness of growth in the plant bed, the amount of suckering, the habit of growth, the resistance to so-called rust and other field troubles, the freedom from shed burn and rib-rot and the length of time required from transplanting to maturity. These attributes are largely a matter of variety and cause no direct increase in the cost of production.

The promptness of growth in the plant bed is important because it decreases the cost of producing plants by lessening the labor of weeding and watering the beds, and also because it permits earlier transplanting, or in case this is not desired the seeding may be done at a later date when the ground is likely to be in better condition for work. In addition less attention will need to be given to enlarging the plant beds than is required where varieties are grown whose seedlings develop more slowly.

Fig. 2. Showing operation of trimming the heads of seed plants after removal of bags. The immature blossoms and pods are trimmed off to secure proper development of seed. This is a group of seed-plants of No. 77, showing characteristic wrinkled leaves.

An upright habit of growth tends to lower the cost of production because it admits of greater ease of cultivation and of the removal of worms when these are picked by hand. Unfortunately, the upright habit of growth in most well known varieties is correlated with

moderate or low yielding power. In this connection it may be stated that a number of the new hybrids of very erect habit are heavy yielders.

Early maturity is of advantage because it admits of more extended periods of transplanting and harvesting the crop, thus allowing the same help to care for a larger acreage than it could if later varieties were grown.

The amount of suckering characteristic of a variety of tobacco is a very important item in calculating the cost of production. The removal of suckers requires a great deal of labor; if this suckering is not done often enough and at the proper times the sucker development greatly reduces the yield and to a less extent impairs the quality. Thus, other things being equal, the more a variety of tobacco tends to produce suckers, the greater will be the cost of its production.

Fig. 3. Various hybrids compared with Zimmer Spanish in plant row test: Beginning at left, Hybrid 127, next, Hybrid 129, central erect row, Zimmer Spanish, fourth row, Hybrid 129, fifth or large row at extreme right, Hybrid 157.

A tendency to diseases both in the field and in the curing house increases the cost of production not only through the reduction in yield and the impairment of quality resulting from the diseased condition of the tobacco, but also by increasing the labor of stripping and grading the tobacco.

ADVANTAGES OF ZIMMER SPANISH AND SEEDLEAF COMPARED

Zimmer Spanish and other varieties of this group possess certain well marked advantages in that they have the upright habit of growth and are prompt growing, early maturing sorts. These Zimmer Spanish types are particularly adapted to the heavier upland soils, where Seedleaf under average care tends to be very late in maturing. They also seem to produce relatively more on thin or poorly fertilized soils than do the larger varieties of tobacco. Furthermore, they cure up more quickly in the shed and are as a rule less liable to damage during the curing process. In addition to these advantages they have, except within the last few years, usually commanded a considerably higher price per pound than the Seedleaf varieties.

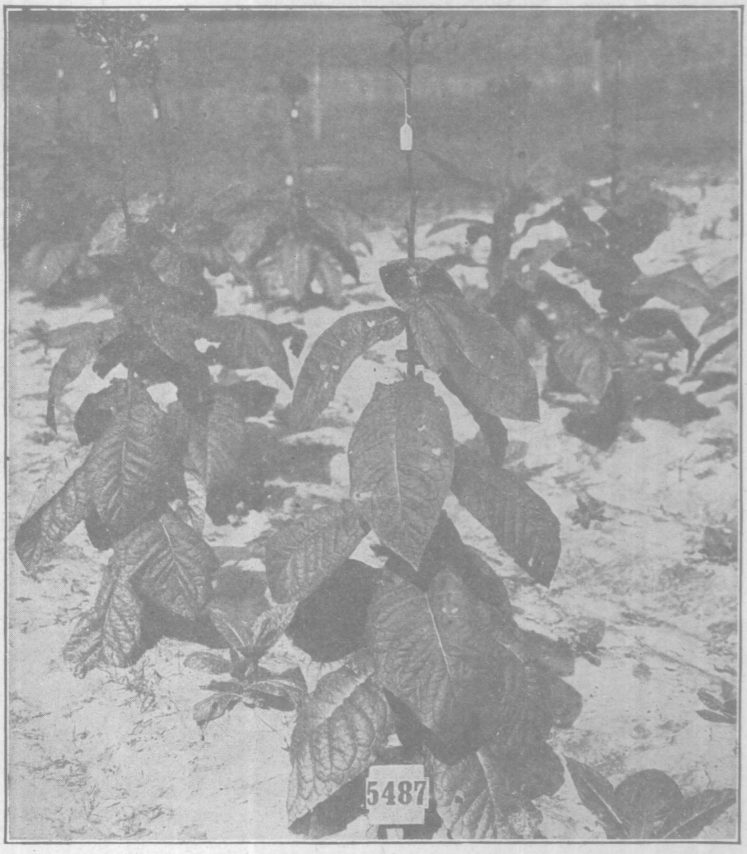


Fig. 4. Seed plants of the Cuban variety, crop of 1910. Note the small, widely scattered leaves. Yield about 600 lbs. per acre. This includes a large proportion of trash.

On the other hand the Seedleaf types have a very decided advantage in the matter of yield, averaging according to conditions from 25 to 75 percent higher for the heavier varieties like Ohio Seedleaf, Pennsylvania Seedleaf, etc., and a much less gain for (Little) Connecticut Seedleaf. They also have the advantage of being especially adapted to the alluvial bottom soils which in many cases are underlaid near the surface with sand and gravel; under these conditions the Spanish varieties rust very badly and often have to be cut long before either good yields or good quality can be obtained. In addition to this the number of plants per acre is much smaller, which, of course, reduces the work of caring for the plants in the field and at stripping time. Seedleaf tobacco is usually cut sooner after topping than Spanish, which reduces the labor of suckering as compared with Spanish. In this connection it may be stated that there are no experimental data to indicate that Seedleaf varieties would prove superior to Spanish in the matter of suckering if both varieties remained in the field the same length of time after topping. When Seedleaf tobacco is left standing long enough, after topping, for Spanish to become properly ripened, the leaves seem to become dead and lifeless and the quality of the crop is reduced, although the yield is greatly increased.

HOW ARE IMPROVEMENTS BEST ATTAINED

The problem which thus presents itself is how can progress best be made in the directions outlined above, which will lead to improvement of our filler tobaccos. Two methods are available: (a) selection from the existing varieties of tobacco and (b) hybridization followed by selection of the hybrid progeny. We may add a possible third method, (c) the growing of first generation hybrids.

SELECTION

Selection offers only opportunity to secure so-called natural variations ("mutants"); that is, in the way of producing really new varieties. There is another very important use of selection, however, which should not be overlooked; this is picking out the best strains or biotypes of which varieties are composed. For varieties of all species of cultivated plants are usually made up of a large number of more or less distinct strains, which have originated either by mutation in the past, or by admixture of other similar varieties, or by accidental hybridization, or by some combination of these methods.

Varieties of tobacco, however, which have been carefully selected seem to partake less of the composite nature so common to other species, as for instance wheat and timothy. This is especially

true of Zimmer Spanish. While many fields of this variety contain some plants which are not of the proper type these seem to have arisen from some chance cross pollination or by accidental admixture of seed of other varieties. When bred out these plants always behave either like hybrids or prove to be of some other variety quite distinct from Zimmer Spanish. In other words, this variety does not appear to be mutating or to have done so in recent years, for upon careful investigation we fail to find a series of types varying about the normal type of the variety. When we breed out a normal looking plant it seems to be identical in hereditary tendency with every other plant of the same variety, but when we select an abnormal looking plant it always behaves like a distinct sort different from the Spanish or else breaks up like a hybrid.

2 1

Fig. 5. Erect and horizontal types of growth in tobacco: No. 1, Hybrid 81, an erect type. No. 2, (1367) Hybrid 75, a horizontal type.

With certain other varieties, Ohio Seedleaf, Pennsylvania Seedleaf, Cuban, etc., some improvement has been made by selection, especially in the matter of yields. This, however, seems to arise, with the exception of the Cuban variety, chiefly from picking out the best types long existing within the varieties and not from finding new and better types of recent mutational origin.

2 1

Fig. 6. Drooping and semi-drooping types of plants: No. 1, (877) Black Seedleaf, drooping type. No. 2, (1522) Hybrid 190, semi-drooping.

Selection is not an exact method unless cross pollination through insect visitation is prevented. This necessitates bagging the plants before any of the blossoms have opened, or in cases where some have already opened they must be removed previous to putting on the bags. When left without protection the percent of blossoms cross pollinated by insects has been variously estimated in different localities and for different varieties of tobacco. Shamel estimated that in Connecticut perhaps 75 percent are self pollinated and 25 percent cross pollinated under ordinary field conditions. From

observations made in Ohio on the progeny of plants which were not bagged though growing in the immediate vicinity of plants of radically different varieties blooming at the same time, we think that less than one percent of the flowers of most varieties grown in the Miami Valley will be cross fertilized when left unprotected. However, this small percentage which is cross pollinated renders it imperative that bagging be carefully done where accurate work is attempted.

TOBACCO HYBRIDS

Hybridization of existing strains or varieties of tobacco offers a sure basis for producing variation and all the manifold opportunities for subsequent selection of the new types so resulting.

How made. Tobacco hybrids are made by cross pollination, the plants being kept bagged to prevent insect visitation. The operation is performed by removing the stamens a short time, usually a day or two, before the pollen matures and the pistil becomes receptive. This is done by inserting the point of a small pair of tweezers into the corolla tube near its base and splitting the tube to the top. Through this opening the five stamens are easily removed by grasping them by their filaments and twisting them off by a quick turn of the instrument between the thumb and finger. When the pistil becomes receptive, which is usually about the time the blossom begins to show pink in color, pollen is applied from the plant selected for the sire. This is most easily done by securing the pollen soon after the anthers burst, lifting one stamen at a time by the filament with the tweezers and gently rubbing the pollen upon the stigma of the pistil. The best time to perform this operation is in the early morning from sunrise to about nine or ten o'clock. Later in the day most of the pollen has fallen from the anthers, which makes the work tedious. The pollination need not necessarily be done as soon as the pistil becomes receptive, for if not pollinated it will remain green and receptive for several days or even a week, but when once pollinated, or rather as soon as fertilization takes place, which is not long after pollination, the tip of the pistil and the corolla tube wither and die. In this work of crossing tobacco, success should result in 100 percent of the blossoms worked.

How handled. These cross fertilized plants are handled the same as others, with the exception that they must be looked after frequently to keep the young buds trimmed off, since these by reason of self pollination would otherwise produce seed which could not be distinguished from that produced by the cross pollinated flowers. In making these hybridizations or crosses, frequently the

flowers on a single plant are divided into several lots by placing tags on the different branches and each group is then treated with pollen from a different plant, thus making several different crosses upon the same pistil parent. In addition, a part of the flowers are allowed to self-fertilize in order that a comparison between the progeny arising from self-fertilized and crossed seed may be possible.

The seed from each distinct hybridization is sown separately and the plants are set in duplicate rows along with the parent varieties and selections of the older hybrids. Observations on their behavior during the growing season are made, and when harvested and stripped their yields and quality are recorded. The best plants are selected for seed and are either planted individually or lumped together. This process is repeated in the second generation, but here it is never wise to mix the seed of two or more plants because this is the breaking up stage. So far as bagging, etc., is concerned the hybrid plants are treated exactly the same as has already been described for the selection work.

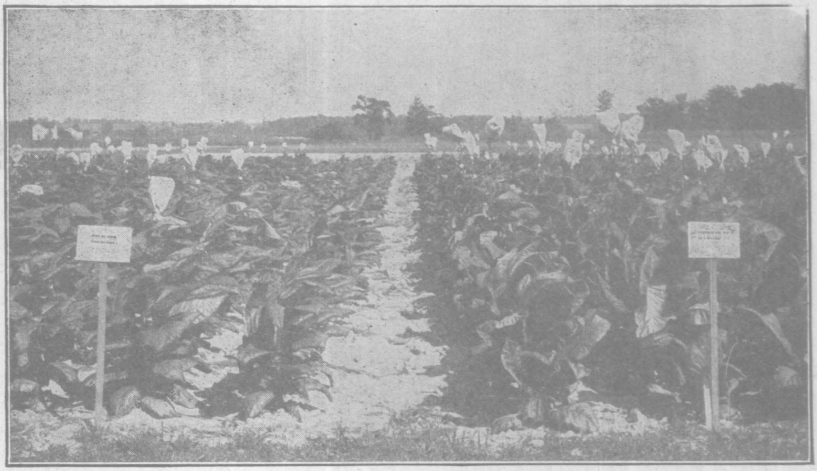


Fig. 7. Plots of Hybrid 77 and Zimmer Spanish showing plot method of comparing varieties.

THEORY AND PRACTICE OF HYBRIDIZATION AND TOBACCO BREEDING

In all hybridization work with tobacco where the ultimate aim is the production of new and fixed types, the theory and practice of cross breeding rests upon the fact that hybridization is the most potent known means of inducing variation; this is all essential in order that there may be obtained, by selection, plants capable of being multiplied into new and valuable varieties. We have already

noted that the more desirable varieties of tobacco already established in the Miami Valley show but little variation and hence afford little chance for improvement without adopting some means of increasing this variation. Especially in the case of Zimmer Spanish, where hereditary variation seems to be entirely lacking, it appears impractical to endeavor to secure improvement by selection without first hybridizing in order to secure variation.

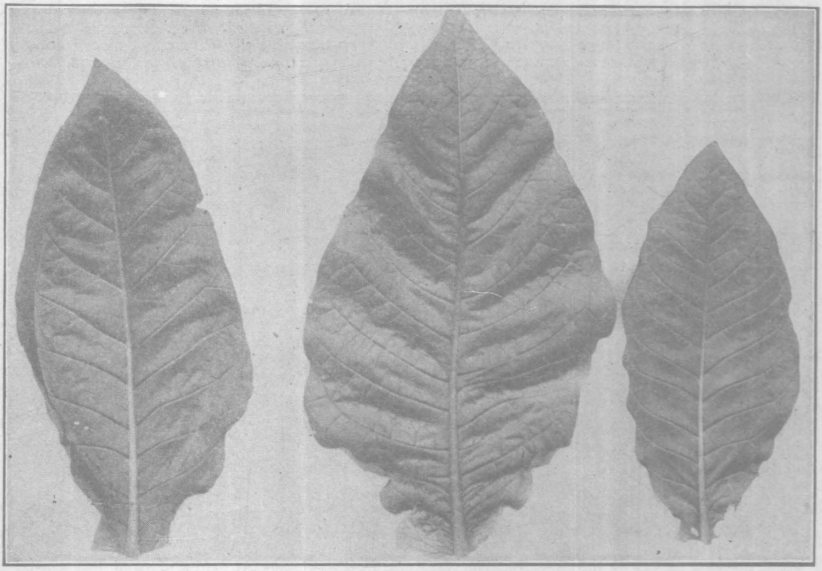


Fig. 8. Under leaf surfaces, and shapes of tobacco leaves: On right, leaf of Zimmer Spanish; in middle, leaf of Ohio or Washington Seedleaf; and at left, leaf of Pennsylvania Seedleaf.

It is true that there are other means than hybridization for inducing variation, one of the most important of which is radical change of environment. This, however, does not affect all varieties alike, and indeed in certain cases like the Zimmer Spanish it seems to have no permanent, that is inheritable effect, at least, not within very wide limits of environmental change. Furthermore, the nature or direction of the change seems more important than its magnitude; thus a variety moved from the south to the north will break up ("mutate") to a much greater extent than a variety moved southward. Apparently, transplanting a variety from a favorable to an unfavorable environment seems much more conducive to variation than the change in the opposite direction. The only very radical variation in tobacco observed in the Miami Valley, due to this cause, occurs in the Cuban variety, which undergoes a rather remarkable breaking up process for the first few years after its introduction

from its native land. We have succeeded in almost doubling the yield of Cuban, and in making other improvements, but long before it can be brought to such a state of excellence as to be able to compete with the already established varieties the breaking up has ceased and there can be but little hope of the production of valuable new varieties from this source.

The character of the variation which arises from hybridization depends upon the fundamental law of heredity, that the inheritable characters of plants are not transmitted as a lump but as indivisible units, each of which is transmitted entire or not at all, and that each unit may be transmitted independently of all the others. Any given visible character of a plant may be due to a single unit of inheritance or it may be the result of two or more, all of which are necessary for the manifestation of the character concerned, but each of which is independently inherited. It is this law that accounts for the appearance, in hybrid progeny, of characters not found in either parent. In cases like these one parent possesses part and the other one the rest of the unit characters necessary for the production of the visible character; when these are combined in the offspring the character appears.

The inheritance of a positive character from but one parent is generally sufficient for its appearance in the offspring, but there are some notable exceptions where in order to be manifested a character must be inherited from both parents. The beards of wheat and horns of cattle are well known instances of this dominance of absence over presence.

The important point in breeding is that a parent either transmits one of these fundamental units entire to its offspring or it does not transmit it at all. Each parent contributes equally to the inheritable traits of the offspring, and the offspring in turn can only pass on to future generations (barring exceptional cases where mutation occurs) the units of inheritance which it has received from its parents. Furthermore, the mechanism of inheritance is such that if an individual has received a unit character from but one parent it will pass on this character to but one-half of its offspring. In other words, one-half of its germ cells will contain this character and one-half will not. When these are bred together, according to the laws of chance, one-fourth will be like one grandparent, one-fourth like the other grandparent and half like the immediate parents. But since each inheritable unit is transmitted independently, in cases where the two parents differ in a number of characters, it is very unlikely that all possible combinations will occur in the second generation, unless the number of offspring be very large. Indeed

the number of possible combinations is the cube or third power of the number of unit characters concerned, and the chance of the rarer of the possible combinations occuring is only as one is to the fourth power of the number of unit characters concerned.

Thus if the two parent varieties of a hybrid differ from each other in ten unit characters we find that there is less than one chance in a million to produce a plant combining in fixed form all the different characters possessed by both parents; that is in the homozygous condition, which simply means that each and every character has been inherited from both parents and therefore must be passed on to all the offspring. Such a plant, if found, would breed true and be the starting point of a fixed variety. Of course there are many other combinations having a greater or less number of the unit characters of the two parent varieties in this "duplex" condition and they also breed true to type.

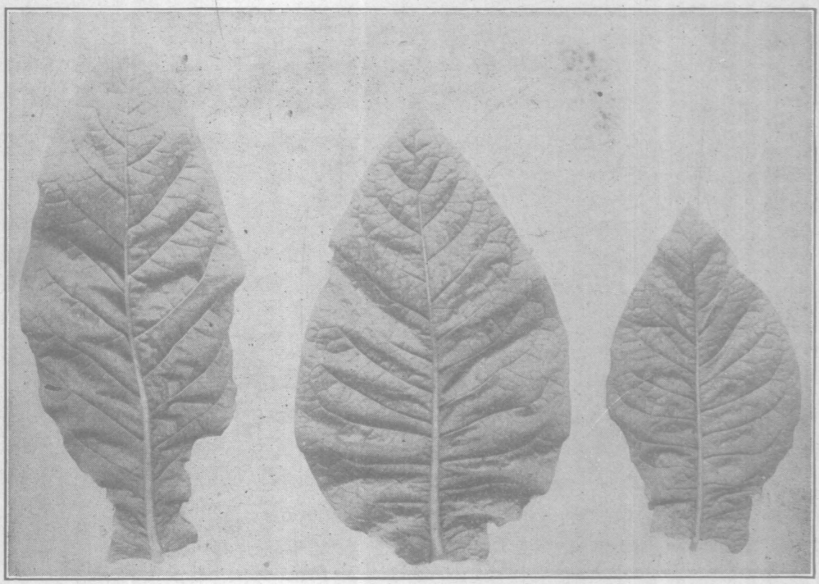


Fig. 9. Leaves of a Hybrid tobacco and leaves of its parent sorts, all lower surfaces. At the right, leaf of Cuban; on the left, leaf of Little Connecticut Seedleaf, and in the middle, leaf of Hybrid 75.

In practice when we succeed in making a new fixed variety by selection from hybrids the probabilities are very strong that the combination of unit characters falls in the latter class, and while in many cases it may be an improvement over either parent the chances are very small indeed that the very best combination possible to be derived from the two parent varieties has been obtained. It is such

facts as these concerning the method of hereditary transmission of characters which make the work so difficult, and yet at the same time open up such boundless possibilities.

From these considerations the necessity of growing very large numbers of hybrid plants in the second and later generations becomes evident, if the highest success is to be attained. It also becomes clear that the greater the difference between the two parents used for hybridization the greater will be the difficulty of producing fixed types of superior worth, but also the greater will be the ultimate possibilities of attaining the highest excellence.

Fig. 10. Different forms of Hybrid 81. On right seed plants of low growing type which is a productive one; on left seed plant of tall type with seed head removed. Both of these yield desirable tobacco.

When all possible combinations occur, two of them are necessarily identical with the two parent varieties. That even close approximation in type and behavior to the parent varieties so seldom occurs, is a further proof of the vast number of combinations which may be secured.

When to the wonderful possibilities of plant improvement from the recombination of unit characters through hybridization we add the possibility, or perhape even probability, that hybridization is in itself a potent cause of mutation, whereby really new units are added to or old ones lost from the heredity of the plants with which we work, we gain some idea of the inexhaustible opportunities for the improvement of plant life by this means, and at the same time we see the futility of expecting valuable results without earnest, sustained, intelligently directed effort.

That progress can be made through hybridization in the case of tobacco seems proven by the results already obtained at Germantown, where many of the strains originated in this way have shown very superior yielding capacity and at least equal smoking quality to that of their parents. In certain respects most or even all of them may be somewhat inferior to some of the fixed varieties, but it does not appear at all improbable that these defects can be remedied by further hybridization and selection.

The work with tobacco is rendered somewhat more difficult than with most species because most of the inheritable units seem to have no individual external expression in foliage, etc., and are only one of two or more factors which when inherited together produce the visible character; furthermore, their manifestations may be modified by their association with other independent characters. In common with other species of plants, in most cases with tobacco it is not possible to determine by superficial examination whether a character has been inherited from both parents or only from one, yet it is only when inherited from both that the character will breed true.

This can be determined only by trial. All pure bred strains of plants and animals receive the same units of inheritance for their important characteristics from both parents, otherwise they could not transmit the same qualities to all of their offspring.

From the above statements we see that all that is necessary for the offspring of a given union to be uniform is that both parents be pure bred, that is, have inherited their unit characters from both parents, and therefore pass them on to all their offspring. It does not matter at all that both parents be alike, because no matter how different they may be, providing only that each is pure bred, the offspring must all receive the same inheritance. We find that no matter how radical the hybridization, we obtain a uniform first generation of hybrid offspring, always more or less intermediate between the two parents in general appearance and habit of growth, although certain features are likely to be more like those of one parent than the other or in "Mendelian" terms these features are "dominant."

The first generation is nearly always more vigorous and more productive than the average of its two parents, in many cases exceeding the yield of the more productive parent. The explanation for this probably rests upon the fundamental relationship of the units of inheritance. It seems probable that the units which have to do with yield are many and act just as effectively when inherited from but one parent as when inherited from both. This being the case it follows that if the poorer parent contains one or more units

which contribute to yielding power not possessed by the other the increase in yield due to these factors are simply added to that of the more productive parent with the net result that the offspring surpasses even the more productive parent.

For the reasons above stated it may be commercially profitable to grow only first generation hybrids. The actual cost of producing the seed is very small in comparison with the increased returns obtained in the crop. See American Breeders Association, Vol. VII, January, 1911.

SECOND GENERATION VARIATION

When plants from seed of these first generation hybrids are grown, as has already been intimated, a remarkable breaking up occurs. If sufficient numbers of plants could be raised some of them would be almost exactly like either parent, and others would be like the first generation hybrids, because according to the laws of chance they would receive respectively the same inheritance as these three classes. But in addition to these there would be many new combinations and thus there is almost no limit to the number of varieties which can be developed by selection from the offspring of a single hybridization.

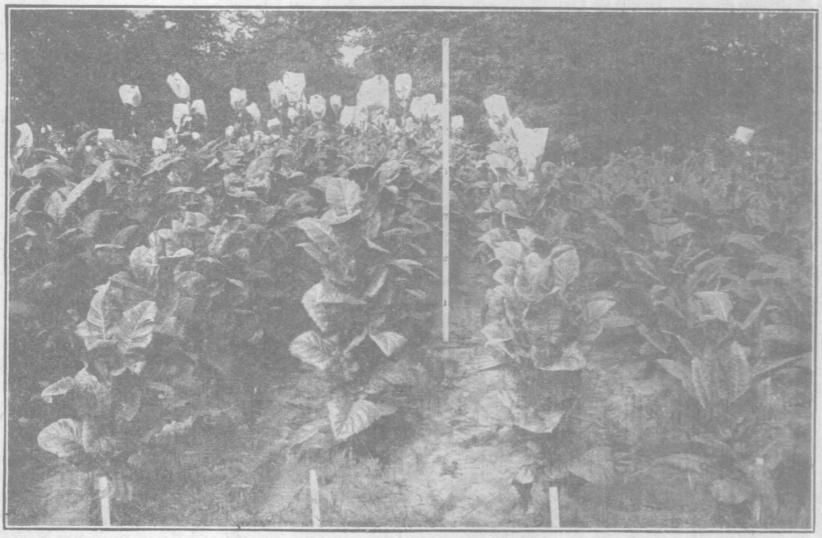


Fig. 11. Hybrid 81, tall type. This occupies the left portion of the figure with row of Zimmer Spanish to right.

The range of variation is very great when two widely different varieties are crossed; the chances are that we get a large increase in yield in the first generation followed by a breaking up into a very large number of strains, some of which will outyield either parent

handsome will even outyield the first generation of the hybrid. But in all cases the average yield of the second and later generations, when no selection is practiced, is relatively low, and especially so when superior parental varieties are used to start with, in which case, however, the absolute yield of the hybrid progeny is better; hence, good varieties are desirable as foundation stock.

Certain plants are often found to be of almost unimaginable worthlessness, having so far lost the habit of growth and vigor characteristic of cultivated tobacco as to be with difficulty identified as belonging to the same species except for the flowers and seed. On the other hand, there may occasionally be found plants of very superior excellence and it is this latter fact that makes the breeding operation worth while.

A certain percentage of plants in the second generation will be found to breed true to type or very nearly so, but most of them will be found to vary in some of their characters so that it usually takes several years to establish a fixed type, depending somewhat upon the amount of difference in the parent varieties and somewhat upon chance in selecting mother plants homozygous in their characters. Of course, in theory we should be able to obtain all possible combinations in fixed form in this generation, but this demands the production of such enormous numbers of plants and the further trial breeding out of so many of them that in practice this can rarely be attained, for there is no known means to distinguish a plant pure in all its important characters from one which is hybrid in some or all of them, other than the lengthy and laborious process of breeding it out and studying the offspring whose uniformity is the single sure proof of the purity of the parent. Therefore, in practice we must content ourselves with fixing part of the characters in one generation and a part in the next and so on until the plant breeds true in all respects.

RANGE OF RESULTS IN THIRD AND LATER GENERATIONS

While in theory it is possible to get all possible combinations in the second generation of hybrids, yet in practice the enormous number of plants required make it impracticable, and we often find new types appearing in the third and fourth and even later generations. This does not necessarily mean that new unit characters have been formed, but simply that new combinations have taken place and that the immediate parents of these later "off-shoot" types have been hybrid ("heterozygous") with respect to some of their characters. These same types would undoubtedly have occurred earlier had sufficient numbers been grown.

Since we can only tell whether a plant is pure ("homozygous") in all its important characters by observing its offspring, we frequently meet with these new types in the third and later generations of our breeding work. On the other hand, several of our most prominent new varieties have shown no variation in type since the initial selection of the parent plant in the second generation. All the descendants of these particular second generation selections have been just as constant as to all external characters as many of the old established varieties. However, there has been considerable variation in yield from different plants, indicating that the original mother plant of the second generation was not pure bred in all the characters having to do with productiveness. In the matter of smoking quality there has also been, in most cases, a considerable range of variation, while in a few, the smoking quality has remained remarkably constant so far as hereditary splitting up is concerned. In common with all other varieties their quality necessarily fluctuates with the season and the care of the tobacco during its growth and subsequent handling.

Fig 12. Hybrids 77 and 81. On left Hybrid 77 with its wrinkled leaves and part of one row cut down; on right low form of Hybrid 81.

Thus we find that the range of variation for all characters is much greater in hybrids than in selections of the old varieties. As a matter of fact, in selections, barring possibly cases of mutation

("sporting") there will be no variation whatever, except such as is temporary and due to environment. The selective process can only pick out the most desirable strains, which, together with other less desirable but closely related strains, make up what are commonly called varieties. The older a variety, the more likely that it contains several more or less distinct types which have arisen by mutation, by accidental hybridization or by the admixture of some other varieties not sufficiently different to be readily distinguished. Most of these mutations occur in a direction which produces plants inferior to the parent strain. Likewise, chance hybridization usually leads to deterioration because perhaps not one plant in a thousand from such an origin would prove equal to or better than the parent sort. The worst of these would naturally be rejected at seed saving time, but many inferior plants more or less closely resembling the true type of the variety could easily be retained even by growers of average carefulness.

Thus it would seem that the chief function of selection from established varieties is to maintain a standard of excellence already attained, rather than to make real advancement. That this is almost all that can be expected from such means we are forced to believe by the results of our experimental work. In other words, by selection we can, in most instances, hope only to get rid of the bad strains which have crept into our varieties by degenerative mutation or other means, and thus restore them to their original state of excellence. Beyond this we do not think it is commonly possible to go, but of course we must bear in mind that valuable mutations do sometimes occur which, if found and propagated, become the foundation stock for new and better varieties. A remarkable instance of this mode of origin is found in the White Burley tobacco, which developed as a sport or mutation from Red Burley in Brown county, Ohio, in 1864.

GENERAL METHODS OF WORK

Before going into the details of the breeding work carried on at Germantown it is well to discuss briefly certain general methods of procedure which are applicable to both selections and hybrids.

Selection of seed plants. Just about the time the plants are coming into bloom seed plants are selected. Each row or plot is usually examined several times, selecting the earlier ones first and making additional selections from time to time as the progress of the plants makes advisable. About the time one-half of the plants have bloomed, that is, have opened the first blossoms, all plants are topped except those intended for the production of seed. This

often necessitates marking some plants which are still too immature for bagging. The marking is done by dropping one of the strings, which are used for tying on the bags, across the head of the plant and working it between the young buds by gently pulling downward upon both ends of the string.

Method of bagging. The plant is prepared for bagging usually about the time the first blossoms open or a few days later, by trimming off all the leaves above the point where the plant would usually be topped, and removing the lateral branches of the flower cluster except a few in the very top. Any blossoms that may be open are also removed. The bags, which are usually five or six pound grocer's paper bags, are then placed over the top, leaving the bottom of the bag about an inch above the top of the plant; the edges of the bag are then gathered evenly about the stalk by a quick movement of both hands while a piece of wrapping cord is wound three times around and drawn tight in a half knot, which holds perfectly.

Fig. 13. Hybrid 89 on left, Zimmer Spanish on right. Crop of 1910 Southwestern Test Farm, Germantown, Ohio. Hybrid 89 grew a yield of 1900 lbs. per acre; Zimmer Spanish 960 lbs. per acre in this planting.

The stalk elongates rapidly for a short time after it is bagged, and when the bottom of the bag is seen to be pushed up by the growing top it is time to raise the bag; this can best be done by taking hold of the sack with both hands, where it is tied to the plant

keeping the elbows against the sides to steady the arms and slowly but firmly push the bag up several inches, usually as far as the remaining floral branches will allow, for by this time the stalk has become strong enough to support the bag, and its entire capacity should be made available for the expanding seedhead.

It is very important not to use very large bags, at least in the Germantown district, as windstorms of sufficient force to break the tops from many plants are quite frequent. Even with five or six pound bags there is considerable loss from this source, yet bags smaller than these do not allow sufficient room for the proper development of the seed. It is also important that the bag be not placed upon the stalk while too young, as this is almost certain to result in the loss of the top if a windstorm occurs within a few days, as when not actually broken off the tops become very crooked and are then likely to be twisted off by a windstorm from another direction.

After the bags have remained upon the plant from two to four weeks, according to the number of seed pods wanted, they are removed and all the fertilized flowers and buds are cut off with a small pair of scissors. In case it is desirable to harvest the seed at an early date the small pods are also cut off. See illustration, Fig. 2.

Labeling. When the bag is placed upon the plant a string tag label, bearing the date of blooming of the first bud as nearly as can be judged, is placed upon the stalk just below the bag. Later its individual record number as well as the row or planting number is added, and a duplicate label is placed upon the stalk just under the top leaf, so that the seed can be identified with its stalk in the curing shed. When the tobacco is stripped a cloth label bearing the same number is placed in the hand of tobacco which is made from each individual seed plant. After being fermented these hands are manufactured into cigars for the smoking test.

Preliminary rejection of seed plants. After the seed plants have completed their vegetative or leaf growth they are carefully gone over and the seed heads removed from many of the poorer plants, which are then harvested with the bulk lot of each row or plot. This preliminary rejection of seed plants usually amounts to nearly one-half of the total number originally selected.

Keeping the individual plant record. Before the seed plants are harvested each one is measured and a record is made of its chief characteristics. In addition to recording the measurements, notes are taken on the important characters of the plants. The items covered in the individual plant record at this time are as follows: (1) The plot or row number. (2) The individual record numbe-

(3) The date of blooming. (4) The habit of growth. (5) The color of the leaves. (6) The amount of suckering. (7) The height to the top leaf. (All measurements are given in inches.) (8) The total height of the plant. (9) The length of the largest leaf. (10) The width of the largest leaf. (11) The length of the top leaf. (12) The width of the top leaf. (13) The number of leaves. (Under this heading is also recorded the number of leaves, if any, which have died off at the base of the plant.) (14) Special notes, which are given only in cases where some special excellence or defect either in the plant itself or in its environment seem to demand particular mention.

Later the average length of the internodes and the approximate leaf area of the plant in square feet are calculated from the foregoing data. The field grade is then made up by adding together the points credited to the plant for its particular degree of excellence in each of the characters already considered. This grade as used has no reference to 100 or any other number as a standard of perfection, is not based upon the percentage system and is not intended to be a complete estimate of the plant even from the field standpoint, but it has been found very useful in making comparisons between individual plants of the same plot or row and for making wider comparisons when used in connection with other data.

Fig. 14. Hybrid 182 with Hybrid No. 54, Germantown, Ohio, 1910. On the left is shown Hybrid 182, which is a tall productive hybrid of Pennsylvania Seedleaf and Black Seedleaf. On right Hybrid 54. See table of yields, 1910.

O. A. E. S. TOBACCO BREEDING—INDIVIDUAL PLANT RECORD

Department of Botany, Germantown, Ohio, 1910

Plot	Variety	Progenitors		No. of seed plant	Record No.	Date of blooming	Habit of growth	Color	Suckers	Height*		Larg'st leaf*		Top leaf*		No. of leav's	Av. length of internodes*	Approx leaf area sq. ft.	Wt. cured leaves ounces	Field grade	Sm'king grade	Special notes
		Grandparent	Parent							To top leaf	Total	L'th	W'th	L'th	W'th							
652	199	51	162	225	1459	8-13	D.	G.	G.	36	60	27	15	21	10	17	2.12	17.0	6.50	12		
653	199	57	179	237	1460	—	S. E.	G.	V. G.	31	57	27	18	22	9	18	1.72	19.9	7.50	29	90	Prom.
653				238	1461	8-12	S. E.	Dp. G.	V. G.	30	53	24	17	23	9	17	1 76	17.3	7.50	23		Good
653				239	1462	8-16	E.	G.	V. G.	31	58	25	16	21	10	18	1.72	17.9	7 75	34	95	V. Prom.
653				240	1463	8-17	S. E.	G.	Exc.	37	64	27	16	20	11	21	1.76	22.2	9.00	44	92	V. Prom.
653				241	1464	8-13	S. D.	G.	V. G.	37	70	28	17	21	11	22	1.68	25.1	9.50	42	92	V. Prom.
654	206	104	212	3014	1465	8-17	S. E.	D. G.	V. G.	28	55	27	19	19	10	20	1 40	22 3	7.50	29		
654				3015	1466	8-18.	S. E.	G.	G.	34	64	24	14	21	8	20	1 70	16.5	7.50	21		
654				3016	1467	8-16	S. D.	D. G.	G.	33	64	24	14	20	9	20	1.65	16 9	8.00	21		
654				3017	1468	8-19	S. D.	D. G.	G.	26	50	24	14	22	10	17	1.53	15.6	7.00	18		
654				3018	1469	8-19	D.	D. G.	G.	30	57	28	16	21	9	18	1.67	18.4	7 00	18		
655	204	105	231	3023	1470	8-18	S. D.	V D G	G.	46	74	23	15	18	10	21	2.19	18 0	8.00	29	89	V. Prom.
655				3024	1471	8-18	H.	D. G.	G.	38	62	23	14	20	11	21	1.81	18 8	8.25	33	94	V. Prom.
655				3025	1472	8-16	H.	V D G	V. G.	39	61	25	16	19	8	21	1 86	18.5	8.50	32		V Prom.
655				3026	1473	8-14	H.	V D G	G.	37	65	26	17	21	12	19	1.95	21.5	8.00	26	92	Prom.
655				3027	1474	8-17	S. E.	V D G	G.	44	67	25	15	16	10	21	2 10	17.5	8 00	26		Good
655				3028	1475	8-10	S. D.	V D G	V. G.	39	63	23	14	20	11	20	1.95	17.9	7.75	25	89	Prom.
656	89	3007	4004	5008	1476	8-16	V. E.	Dp. G.	V. G.	39	69	19	13	15	8	21	1.86	12.5	6 00	24		V. Good
656				5009	1477		V. E.	Dp. G.	V. G.	41	70	20	14	18	9	22	1.86	16.0	6 75	29	92	Prom.
656				5010	1478	8-18	V. E.	Dp. G.	V. G.	35	65	20	12	18	9	21	1 67	14 0	6.50	29	91	Prom.
656				5011	1479	8-17	V. E.	Dp. G.	V. G.	40	70	18	13	16	8	22	1 82	13.1	6.75	28	94	Prom.
656				5012	1480	8-17	E.	Dp. G.	V. G.	40	72	23	14	18	8	23	1.74	13 1	8.00	35	79	V. Prom.
657	54	4108	5092	6043	1481	8-12	H.	G.	V. G.	41	70	22	15	19	9	25	1.64	20.5	7.50	25		
657				6044	1482	8-16	S. E.	L. G.	G.	43	69	19	11	16	7	24	1.79	12.6	5.75	19		
657				6045	1483	8-15	S. E.	L. G.	V. G.	40	66	19	12	18	8	25	1 60	15 4	5.50	22		
657				6046	1484	8-16	S. E.	G.	G.	42	69	21	13	20	9	22	1.91	16 5	7 75	23		Good
658	· Zimmer check				1485	8-4	E.	D. G.	G.	27	58	22	11	22	10	16	1.69	13 3	6 00	21	90	V. Good

*These measurements in inches.

In addition to the above data the name of the variety or the number of the hybrid and the seed plant, as well as the number of the parent and the grandparent plants are recorded. These latter furnish the connection with preceding records needed for tracing pedigrees. The record of each plant is finally completed by assigning it an individual seed plant number which is distinct from the record number and not only serves to distinguish its possessor from other plants of the same variety but also shows how many generations have elapsed since the hybrid was made, or in case of selection since the original mother plant was discovered.

The preceding is a sample page from the individual plant record of 1910. This page includes records of certain seed plants of several important hybrids, among which may be mentioned hybrids 89, 199 and 204. It also contains the record of a very fine plant of Zimmer Spanish.

The plant's pedigree. By examining the individual plant records for the various years we can obtain the complete history of any seed plant and of all its progenitors back to the time when the hybrid to which it belongs was made, by the cross pollination of two plants of different varieties; or in the case of selections we can trace the history of the particular strain back to the original mother plant selected from the general planting of the variety. In the hybrids we can go a step farther, for we have the history of the two parent plants from which each hybrid was produced, and in nearly all of the later hybrids we can also trace the ancestry of these parent plants back through several generations.

From the study of this pedigree we can know just what have been the main characteristics of the ancestral plants of each and every plant which has been saved for seed, and in connection with the field records we can also learn of the characteristics of the sister plants of each seed plant and also those of each of its progenitors. Thus we learn whether we are dealing with a fixed strain or with a hybrid which is still varying. If fixed, we know in just what generation in the past this fixity of type has been secured. If still varying we can study this attribute both as to amount and direction and thus know whether the strain is improving or degenerating. To be able thus to trace the yield and quality, habit of growth, date of maturity, etc., back through a number of generations, is very helpful in deciding which strains to discard, which to endeavor to improve by further selection and which ones are already fixed varieties.

Field testing of the progeny of individual seed plants. A seed plant is of value only in so far as it is able to transmit valuable

qualities to its descendants. It does not always happen that the plant possessing the greatest individual merit will prove best for seed purposes. The excellence of a plant may be due to environment, in which case, of course, it will not be transmitted to the offspring. Or in the case of unfixed hybrids it may be due to a peculiar combination of hereditary characters which will be transmitted to but a small portion of the offspring. Seed plants of first generation hybrids fall in this class. In this instance, notwithstanding the fact that such a plant may be of great value for breeding purposes, so far as concerns the immediate production of a crop of tobacco it has no value as a seed plant. Now there is no way by which we can know to a certainty which seed plants will prove capable of producing good crops except by trial.

Necessity of check rows or plots. The object of checks is to furnish a standard by which the various hybrids and selections may be measured, not only as to yield but also as to date of maturity, habit of growth, amount of suckering and in fact everything which is influenced by change of environment. If all the soils used in the breeding work were absolutely uniform and if all the transplanting could be done in one day and all other operations could be performed in the same manner and at the same time for the whole area, the check rows would be of no use. But since these conditions cannot be met it is very necessary that some one variety be planted at frequent intervals throughout the testing grounds in order that the various hybrids and selections may be compared with these checks which, so far as heredity is concerned, are all equal. This enables us largely to overcome the differences of yield, etc., due to environment. In the breeding work at Germantown where the row method is followed a check of Zimmer Spanish is planted each sixth or seventh row while in the plot method every fourth or fifth one is planted to Zimmer Spanish.

Duplicate plantings. Still further to reduce the chances of error each strain is grown in duplicate and widely separated rows or plots as the average of two separate plantings is more likely to indicate the true value of a variety of tobacco than the results of a single test. Even with frequent check rows there may be some marked increase or decrease in fertility between two checks due to some unknown cause, frequently differences in past treatment, especially to variations in the application of manure or fertilizer. There is much less chance that two distinct and widely separated plantings of a particular strain will both be planted on especially good or on especially poor soil than there is for this to occur with but a single planting.

1 2

Fig. 15. Hybrid 199, a most promising Seedleaf hybrid. No. 1, topped seed plant of 1910; No. 2, heavy producing seed plant of 1911.

DISTURBING FACTORS

A certain amount of error is bound to arise from our inability completely to control the various factors of environment which influence yield. That arising from unknown differences in the fertility of the soil has already been alluded to. Another disturbing factor arises from unequal spacing of the plants in the rows and to a still greater extent from the rows being unequally distant from each other; for those rows which have the most room manifestly have an advantage over those planted closer together. Again we find a disturbing factor in certain differences in adaptability to certain types of soil, to certain methods of treatment and to certain kinds of weather. Thus we find that certain varieties and hybrids are better adapted to wet seasons and that others do better in dry years, while they may be nearly equally adapted to average conditions or when a period of several years is considered. There is also much difference in the relative adaptability to different types of soil; of two varieties one may prove the better on the ordinary upland soil of this region while the other variety will give better results upon red soil. Similar differences exist in the relative adaptability to black soils and to the alluvial bottom lands. The difference in the adaptability between Zimmer Spanish and Seedleaf to upland and bottom soils is a well known fact, Zimmer Spanish being better adapted to upland and Seedleaf to the river valleys.

Again varieties differ in their adaptability to various systems of rotation or to continuous culture. For instance, hybrid 54 is less adapted to continuous culture than Zimmer Spanish and the records show that while yielding more than Zimmer Spanish under either system, the gains over the latter variety are much greater when grown in a three-year rotation of tobacco, wheat and clover than when grown on ground continuously in tobacco. This condition prevails regardless of the fertility of the soil or the absolute yields obtained. In fact, there is scarcely any factor of environment, using the term in the broad sense to include everything which is done to the crop as well as the condition of the soil and weather, to which any two distinct strains would be equally well adapted. It is quite obvious that failure to sucker two varieties of tobacco would injure more the one which produced suckers the more freely. So cutting too soon would reduce the yield most in varieties which make the greatest gains during the ripening process. The date of maturity reacts with the weather conditions, sometimes in favor of early varieties and sometimes in favor of later ones. Sometimes we find that an early variety will complete its development before being caught by a severe drouth. At other times the drouth may come a

little earlier and the early varieties be forced to complete their growth under adverse conditions while the later sorts may be still capable of vigorous growth after the return of favorable weather. In this case the later varieties have a decided advantage while in the former the advantage is with the earlier variety.

This factor, of course, will be largely modified by the time of transplanting and the fertility of the soil which always help determine the date of maturity. In the season of 1910 an early planting of Zimmer Spanish and one of our hybrids produced nearly equal yields, while a planting of the same sorts made about two weeks later on a similar soil produced very different yields, the hybrid making almost twice as many pounds per acre as the Zimmer Spanish. The explanation lies in that in the earlier planting the hybrid completed its development in very hot, dry weather while the Zimmer Spanish had matured before the advent of the drouth. In the later planting, however, the Zimmer Spanish had to complete its development in this unfavorable weather while the hybrid was still in condition for vigorous growth when the drouth was broken and completed its development under very favorable conditions, making a remarkable growth in the last two weeks.

Last to be considered, but not least of the disturbing factors in obtaining accurate measure of the productive power of different strains of tobacco, is the variation in the size and condition of the plants at transplanting time. We have found that large, strong plants in certain seasons, especially when the transplanting is followed by hot, dry weather, will produce a very much greater yield than will the same strains grown from small or tall, slender (spindling) plants. When the weather is favorable throughout the season there probably will be but little difference of yield due to the size of plants used, but there will be a difference in the date of maturity, the larger plants maturing first. In very rare instances the smaller plants may out-yield the larger ones, by reason of the more advanced plants completing their development in very dry weather, while the less advanced plants from the smaller sets may still be capable of further growth when normal moisture conditions return, and thus be at an advantage. It is difficult to get plants of exactly the same size at the same time from two different sowings of seed, especially when the plant bed areas are very small as is necessarily the case in our breeding work. The difference in growth in the bed may result from differences in fertility or moisture, from differences in the rate of seeding or from various other causes which cannot be completely controlled.

In selection work best results can be obtained by holding back the more advanced plants and if necessary discarding the first ones

ready. But when this is done the large plants must be removed several days before transplanting, otherwise, notwithstanding that the plants were of equal size, the ones pulled from areas where the larger plants were recently removed would be less hardened to exposure to the sun, and hence would be at a disadvantage.

Fig. 16. A row of a tall type of Hybrid 199. One of the very productive forms recently selected. This row yielded 3693 pounds of wrapper and filler per acre.

In the case of unfixed hybrids there are grave difficulties in the way of discarding the earlier plants for we may thereby lose all the plants of a certain type which for aught we can tell at the time may be the very best of the whole lot. At any rate we lose those variations which develop rapidly in the plant bed. Prompt germination of seed and rapid growth of seedlings are very desirable characteristics in any variety of tobacco, so it is never wise to reject the first plants ready to set when dealing with a hybrid in the breaking up stage. The only way we have succeeded in even approximately meeting this demand for plants of equal size is to set the plants when they reach the proper size regardless of the order in which they reach this stage. This in many instances makes it impossible to arrange different strains in the field in the exact order desired but this seems less important than giving each variety as nearly as possible an equal chance by having the plants of uniform size.

With all possible care to control the various factors of environment we still at times no doubt obtain rather large differences in

yield due to error rather than to inherent differences in the plants we are testing. As elsewhere stated we have good reasons for believing that the differences in yield of the various selections of Zimmer Spanish are attributable almost entirely to these causes.

THE SELECTION WORK AT GERMANTOWN

ZIMMER SPANISH

The selection work at Germantown began with the Zimmer Spanish variety in 1903, and has continued to the present time. A large number of individual plants were selected and their offspring grown in comparison with each other. For a time we thought considerable was being accomplished in the way of increasing the yield of this variety, but repeated and more careful tests in later years seem to show that we really have found few or no inheritable differences in productive power within this variety.

The lack of hereditary variability not only in yield but in all the important characters of this variety has already been noted under the theoretical discussion of selection; to this fixity of type is no doubt to be ascribed in a large measure the long continued popularity of Zimmer Spanish tobacco because it does not degenerate under careless methods of seed selection; but unfortunately for the same reason it does not admit of improvement by this means. We have a number of times obtained from certain growers seed which they termed improved Zimmer Spanish and for which the claim of increased yield, better quality, etc. was made, but in our tests at the Station, which were carefully conducted, no difference in yield quality or any other characteristic could be noted. It now seems clear that the differences obtained in the yield of various selections of this variety arose from accidental variation in certain outside factors rather than from the inherent superiority of certain mother plants. As already indicated the differences in yield between the various selections have during the past few years been less than formerly, no doubt due to the greater care in eliminating sources of error. In practice, however, it is not possible to control conditions of environment thoroughly enough to bring about uniform results; yet the fact remains that the variation in yield among the progeny of individual plants of the same ancestry is just as great as among plants taken at random from the general crop. This is a strong argument against the theory that there are any marked hereditary differences within this variety, though it must be admitted that there is no absolute proof that such variations do not exist. Possibly had the object been the finding of low yielding strains better success would have crowned our efforts, since degenerative mutation

is probably much more common than variation toward greater vigor and productiveness. However, from a study of the data at hand even this possibility of degenerating the variety by selection seems improbable.

The yields of the tobacco grown in 1904 from the original Zimmer Spanish selections made in 1903 were not determined, but two selections which seemed superior were propagated the following year, using a mixed lot of seed for each consisting of four or five of the best plants. These two selections, 31 and 32, yielded respectively 1,030 and 851 pounds per acre. Of the lowest yielding sort six plants were selected for planting in 1906 in which year there were no checks available for measuring the yield of these selections, and moreover, as the rows were planted lengthwise of the plots which had been freshly ridged very great difference in yield occurred. One selection of which but a single row was planted and that on the outside of a plot produced the (for Zimmer Spanish) enormous yield of 1900 pounds per acre while the lowest yielding strain produced but 1,133 pounds. At the time it was thought that part of this large difference in yield was due to hereditary differences in the mother plants, but the behavior of later generations indicate that this assumption was erroneous. Of the higher yielding selection in 1905, number 31, but two seed plants were used in propagating the strain. These made yields of 1,600 and 1,325 pounds respectively. Doubtless had as many individual plants been propagated as in the other strain there would have been just as wide variation in yield; as a matter of fact the average yield of all the individual seed plants were just about equal for these two strains. The next year (1907) the seed of one or more plants of each of the best yielding selection of the two strains were grown individually with the hope of obtaining superior yielding strains of Zimmer Spanish tobacco.

This year, however, all plantings were made in duplicate and great care exercised in the matter of check rows and considerable pains taken to have the plants of uniform size both for the selections and for the checks. However, the plants of the selections were slightly inferior to those used for the check rows as they had to be pulled too closely owing to the small size of the bed areas; this probably accounts for their somewhat lower average yield which was 73 pounds below the checks of unselected Zimmer Spanish. The largest yield was 1,022 and the lowest 849 pounds per acre, making the extreme range of yield only 173 pounds as against 767 pounds per acre the year previous. The average yield per acre for both selections was 926½ pounds and the average difference in yield but one pound, selection 32 producing 927 and selection 31 926

pounds per acre. The highest individual yield was 95 pounds above and the lowest 78 pounds less than the average, differences well within the limit of error. The average deviation from the mean yield was only 31 pounds per acre. These results were not such as to encourage the hope of improving the Zimmer Spanish variety materially by selection, but the work was continued with very similar results in 1908 and 1909, although in the year 1909 we have no data for selection 31.

Other selections made at various times and from various sources since 1903 have been grown through several generations with very similar results to those obtained with the two selections just described. Therefore we are ready to abandon the strains of Zimmer Spanish which have been tested but shall continue each year to test a few new selections from various sources in order, if possible, to find a valuable variation and if not to add to the abundance of proof already at hand that this variety does not admit of improvement by selection.

In this connection it is well to state that several times old Zimmer Spanish seed has been obtained and grown in order to test the validity of the claim that Zimmer Spanish is running out and does not yield so well as it used to and that the leaves are not the same shape as formerly. In 1906 seed fifteen years old was obtained from Mr. John Rohrer, a tobacco merchant of Germantown, Ohio. The plants produced from this seed, which germinated nearly as well as new seed, were indistinguishable in every respect from the remainder of the Zimmer Spanish grown at the Test Farm and made about the same yield. The next year the progeny of two plants selected from the lot grown in 1906 yielded respectively 80 and 36 or an average of 55 pounds more per acre than the check rows; however, they were not duplicated and as other selections planted near them made corresponding gains over the checks, we must attribute even this small gain to better plants or other extraneous causes and not to heredity, for we find that the other selections which here made similar yields to the old Spanish, in their *duplicate* plantings fell below the check.

Again in 1910 old seed was obtained; this time from a tobacco company in Miamisburg, Ohio, for which the claim was made that it had passed through but two generations since the original supply had been obtained from Jacob Zimmer himself, who was supposed to be the originator of this tobacco bearing his name. (For a discussion of the real origin of Zimmer Spanish see Bulletin 238, pages 340-3). The results of growing this old Zimmer in 1910 were as follows: Of three plantings one produced five pounds less, one four

pounds less and one eleven pounds less than the checks alongside. This surely is not an evidence of any great change in productive vigor. The tobacco, like that from the old seed obtained from Mr. Rohrer, appeared exactly like the ordinary Zimmer Spanish of today.

This is probably the place to call attention to the results obtained with Connecticut Havana, sometimes called Connecticut Havana seed. Our experience has been that this variety and Zimmer Spanish are one and the same thing. In 1906 some so-called improved Connecticut Havana seed was obtained from Connecticut with the result that no difference could be detected between it and Zimmer Spanish from Ohio grown seed. In 1907 some Connecticut Havana from Wisconsin grown seed produced five pounds more per acre, of tobacco which was indistinguishable from the Zimmer Spanish grown alongside. In 1908 a new supply of Connecticut Havana seed was obtained directly from Connecticut. It resulted in a gain of three pounds for this year and of thirty pounds in 1909 over the Zimmer checks. The tobacco, as in the case of this variety grown from seed from other sources, was indistinguishable from Zimmer Spanish. In all these trials of Connecticut Havana the variation from Zimmer Spanish in yield has been extremely small, with no apparent difference in other characters; this not only tends to show that Zimmer Spanish and Connecticut Havana are but a single variety, but is a further strong proof that this variety is one of remarkable fixity of type since even radical changes of environment do not produce inheritable variation.

TABLE I. Yields of selections of Zimmer Spanish, Ohio Seedleaf, Pennsylvania Seedleaf and Cuban. Increase per acre over Zimmer Spanish checks.

Variety and Selection	1905		1906		1907		1908		1909		Average	
	Lbs.	Per-cent	Lbs.	Per-cent	Lbs.	Per-cent	Lbs.	Per-oent	Lbs.	Per-cent	Lbs.	Per-cent
Zimmer Spanish No. 31	30	3 5	−37	−2.5	−74	−7.1	4	.4	....	.....	−19	−1.4
Zimmer Spanish No. 32	−149	−12.9	34	2.3	−73	−7.0	11	1.2	−12	−1.3	−38	−3.5
Old Zimmer Spanish	.....	.....	−43	−3.0	55	4.5	..	...	−7	−.6	2	.2
Connecticut Havana*	.....	.....	....	.....	5	.5	3	.3	30	4.4	17	2.4

Variety and Selection	1906		1907		1908		1909		1910		Average	
	Lbs.	Per-cent	Lbs.	Per-cent	Lbs.	Per-cent	Lbs.	Per-cent	Lbs.	Per-cent	Lbs.	Per-cent
Ohio Seedleaf, Unselected	401	44.6	...	....	...	....	...	....	...	..	...	....
Ohio Seedleaf No. 1	...	....	488	56.9	512	46.9	621	62.8	522	51.6	536	54.5
Ohio Seedleaf No. 5	...	....	451	41.2	331	28.6	416	44.1	605	50.8	451	41.2
Pennsylvania Seedleaf, Unselected	365	40.6	391	44.1	...	....	...	....	...	....	...	...
Pennsylvania Seedleaf No. 1	...	....	300	32.5	...	....	...	....	...	....	...	....
Pennsylvania Seedleaf No. 9	...	....	472	52.9	287	28.9	557	62.9	396	30.9	428	43.9
Pennsylvania Seedleaf No. 11	...	....	298	33.6	...	....	...	...	...	....	...	
Pennsylvania Seedleaf No. 12	...	....	493	57.3	439	43.7	542	67.9	452	39.6	482	52 1
Cuban, Unselected	−608	- 50.4	−449	−43.0	−397	−41.8	−468	−50.3	−478	−43.0	−480	−45.7
Cuban No. 102	−525	−37.5	−261	−26.8	−226	−23.7	.....	.....	.....	.....	−337	−29.3
Cuban No. 107	−404	−44.9	.....	.....	.....	.....	.....	.....	.....	.....	... .	.. .
Cuban No. 154	−900	−64.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Cuban No. 6	.....	.....	−172	−20.1	−156	−15.3	−261	−32.6	.....	.....	−196	−22.7
Cuban No. 14	.....	.....	−200	−24.0	−332	−31.1	.....	.....	.....	....	−266	−27.6
Cuban No. 24	.....	.....	−248	−27.5	−124	−12.7	−192	−23.3	−312	−26.8	−219	−22.6
Cuban No. 193	.....	.....	−266	−25.3	−194	−21.6	−266	−32.7	−223	−19.9	−237	−24 9

*See page 396

OHIO AND PENNSYLVANIA SEEDLEAF

Ohio and Pennsylvania seedleaf were first grown at the Station in 1906, the former producing an increase over Zimmer Spanish of 401 pounds per acre or 44.6 percent while the latter yielded 365 pounds or 40.6 percent more than the same variety.

By referring to Table I and Fig. 17, which give the results of the selection work with these varieties from 1906 to 1910, it will be noted that the same ratio does not exist between the different selections in their gains in pounds per acre as in their percentage gains. This is explained by the fact that these selections were not always planted upon equally fertile soil, the Zimmer Spanish checks between which they grew thus varying in yield. The percentage gains are given because it has been found a much better index to the real productive capacity of varieties than the gain in pounds per acre. For instance, a variety which produces 300 pounds more per acre than Zimmer Spanish where the latter yields but 750 pounds will in all probability produce a much larger increase under conditions where Zimmer Spanish produces 1500 pounds per acre. On the average under these conditions the increase will be about twice as great or 600 pounds, making the total yield 2100 pounds per acre; in other words maintaining a constant percentage gain over the checks. Some hybrids and varieties are exceptions to this rule but usually we find that where the same two varieties are planted together in two or more places differing in fertility, the percentage gains of the higher yielding sort over the lower are much more nearly constant than the gains in pounds per acre. Therefore, in all cases where it is necessary to detect small differences in yielding power the percentage system should be employed. This is especially true where there is wide divergence in the yields of the check and the varieties tested.

The seed from 4 plants of Pennsylvania Seedleaf selected in 1906 were sown in 1907, resulting in the following yields: Selection number 1 produced 300 pounds per acre or 32.5 percent more than the Zimmer Spanish; Selection 9 made a gain of 472 pounds or 52.9 percent; Selection 11 gained 298 pounds or 33.6 percent; while selection 12 made the largest increase of all amounting to 493 pounds per acre or 57.3 percent; the unselected seed for this year produced 391 pounds per acre or 44.1 percent more than Zimmer. These four strains were all very similar in type but some slight difference could be noticed on close inspection; there was no evidence of variation within the different selections nor has any since developed. The two poorer yielding selections were at once discarded. The

results obtained from 1907 to 1910 for selections 9 and 12 while varying widely in their gains over Zimmer Spanish from year to year according to weather conditions, were very consistent in regard to each other. The average gain for the four years being 428 pounds or 43.9 percent for selection 9 and 482 pounds or 52.1 percent for selection 12.

CUBAN

As previously stated under the general discussion of selection as a means of improving tobacco, Cuban is the only variety with which we have experimented whose mutations are of sufficient magnitude and frequency to enable the breeder to make material progress by selecting the offspring of a single mother plant which together with its immediate progenitors has been so handled as to prevent cross pollination. Under our conditions the Cuban variety undergoes a marked breaking up in type similar to that occurring in hybrids between radically different varieties, although the range of variation is not so great for the Cuban as for such hybrids. In 1905 a number of of seed plants of the Cuban variety were bagged and the seed thus saved free from cross pollination. This strain of Cuban had been propagated in this manner from bagged seed for two years previous to starting this experiment, selecting each year a number of the best plants and mixing the seed together. Thus what in Table I and Fig. 17, is termed unselected Cuban has in fact been selected in this manner but not by the better and more accurate method of testing out individual plants. There is no doubt that the yields obtained were in excess of those which would have occurred had no selection whatever been practiced. For two of the years, 1907 and 1910 no unselected Cuban, using the term in the restricted sense above noted, was grown, the yield for these years being calculated by taking the average percent of the Zimmer Spanish yield of the other three years covered by the table. The variety termed Vuelta De Abajo is included with the Cuban since the only difference we have been able to detect is a slightly darker color of the leaves. In the table all the yields are stated as so many pounds or a certain percent less than the yield of Zimmer Spanish.

The diagram Fig. 17 shows graphically the results of breeding out several selections of this variety. This diagram is developed upon the basis of a yield of 1000 pounds per acre for Zimmer Spanish which is very close to the actual average yield of this variety for the period covered. The yield of the selections as well as the unselected Cuban for the various years is determined by taking such percentage of 1000 pounds as the actual yield of the Cuban strains bore to the yield of the Zimmer Spanish checks between which they grew.

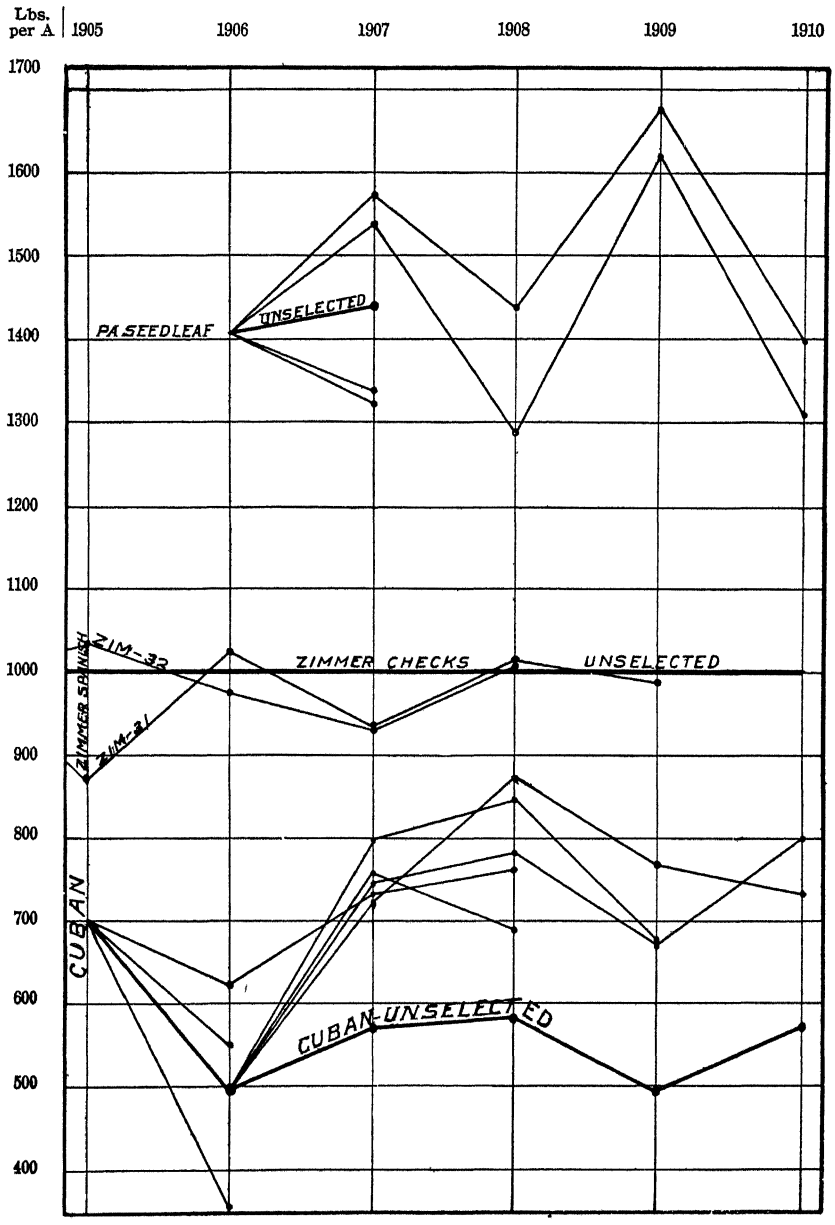


Fig. 17. Diagram showing the results of selection work with Zimmer Spanish, Pennsylvania Seedleaf and Cuban for the years 1905-1910. The diagram is built upon the basis of a Zimmer Spanish yield of 1000 pounds per acre. The other yields are calculated by taking such percentages of 1000 as the actual yields were of the yields of the Zimmer Spanish growing alongside.

Starting at the left we find the yield of unselected Cuban for 1905 to be about 70 percent of that of Zimmer Spanish which is much higher than in any of the later years, and is probably due to error as the checking system at that time was very defective. Of the three seed plants propagated individually the next year, two produced more than the bulk lot, and one less. Only the best yielding strain was continued the following year, being represented by two seed plants with results as shown by the diagram. This strain was discontinued in 1908. Going back to 1906 we find three new mother plants selected which produced yields ranging from 72 to 80 percent as much as Zimmer or nearly one-half more than the unselected Cuban. These strains have been continued by using a single seed plant apparently the best one each year. By this practice the relatively high yields obtained from the mother plants in 1907 have been just about maintained. While we can not state positively what results would have followed selecting the poorer appearing plants from year to year in these strains, the probability is that a considerable lowering of the yield would have resulted, for these Cuban selections show a lack of the great uniformity so characteristic of strains of other varieties descended from a single mother plant.

From the data already considered it becomes clear that the Cuban tobacco admits of a very considerable improvement in yield by selection and the same may be said in regard to reduction of the sucker growth which is so very objectionable with this variety. By this means we have been able to increase the yield from slightly over one-half to slightly more than three fourths of that of Zimmer Spanish; an increase amounting to about 50 percent of its own unselected yield. Nevertheless the starting point is so low both as to yield and other desirable characters with the single exception of smoking quality, that no practical results have been obtained and none seem possible of attainment by selective breeding unaided by hybridization. This tendency to great variability and breaking up of type shown by Cuban tobacco even after a number of generations of careful selection is probably in some degree transmitted to its hybrid offspring, since this would explain the peculiar behavior of certain strains of Cuban-Connecticut Seedleaf hybrids which after apparently having become fixed types have undergone remarkable hereditary modifications that are very difficult wholly to explain by segregation and recombination of unit characters.

THE GERMANTOWN TOBACCO HYBRIDS

Before going into a detailed discussion of the individual hybrids we shall take a general survey of the hybridization work carried on at the Germantown Test Farm since 1903. This work was begun in that year by making 26 distinct crosses between the Connecticut Seedleaf and Cuban varieties. The following year in addition to propagating these first made hybrids a number of new ones were made between them and Ohio Seedleaf and Zimmer Spanish; also one each of Zimmer Spanish by Ohio Seedleaf and Zimmer Spanish by Cuban. The next year (1905) a large number of hybrids were made having for their parents Cuban, Zimmer Spanish, Ohio Seedleaf and several hybrids already made in divers combinations, including a number of intercrosses between different hybrids. Since that time some new hybrids have been made each year, among them are a number, both of whose parents are of Seedleaf types.

From the careful breeding out of these hybrids, about 300 in all, many apparently valuable new varieties have been obtained; some of which are just beginning to be extensively grown by the farmers of this district. Many other types of later development give promise of still greater excellence, but are not yet sufficiently fixed or have not been tested long enough to warrant distribution. In addition to the method of developing new fixed types by hybridization followed by selection we are now investigating the possibilities of growing first generation hybrids upon a commercial scale, thus putting the increased vigor of growth which is so characteristic of them to practical use.

Each year the hybrid work grows in interest, better yields are produced, and other desirable attributes are being attained in larger degree with each passing generation. In Table II are collected the yields of a number of varieties and of the principal hybrids which have been tested long enough to furnish an adequate idea of what may be expected of them when grown upon a commercial scale under the conditions of soil and climate and the methods of culture practiced in the Miami Valley. These yields are not directly given but are stated as so many pounds per acre in excess of those of Zimmer Spanish. In the few cases where the yield has fallen below that of Zimmer, a minus sign precedes the number of pounds. For the years covered by the table the yield per acre of the Zimmer Spanish checks average 950, 930, and 1,111 pounds respectively for the years 1908, 1909 and 1910, making the average for the three years 997 pounds. The rather large increase in yield of the Zimmer Spanish variety in 1910 is probably due to the better fertilization of the breeding plots practiced in that year.

The actual yields made by the hybrids in some cases were lower and in other cases higher than would appear from adding the increase over Zimmer to the average yield of that variety for the year under consideration. This is occasioned by the unequal productiveness of various portions of the ground used for testing out these new sorts. For reasons already stated the percentage gains of each hybrid over the checks is a more accurate guide in estimating their real productive capacity than their gains over the same variety in pounds per acre. But the calculation of the average percentage gain of each strain requires a great deal of work as we have from 600 to 800 separate plantings to deal with each year; therefore this method is followed only in the case of selections where the variation is much less than in hybrids and the necessity for measuring smaller differences in yielding power obvious. In the practice of breeding tobacco it is often well worth while to compute and compare the percentage gains as well as the absolute increase in deciding between two strains, but the gains of the hybrids over their parents and over Zimmer Spanish in pounds per acre are in most cases of sufficient magnitude to be expressed in this way and are entirely adequate for the purposes of this bulletin. In this table the first column under the general heading for each year gives the number of selections of each hybrid or variety grown, the next column gives the average yield of all the selections of each and the third column gives the average yield of the best selection.

The hybrids are arranged in four groups according to their resemblances. In the first group, Havana or Spanish types, are placed those which more or less closely approach Zimmer Spanish and will naturally have to compete with the latter variety in the market. The second group contains those which belong to the Seedleaf class. The third group comprises those which are intermediate between Seedleaf and Spanish. Some of these resemble Zimmer very closely except for their larger size. Hybrids of Cuban and Connecticut Seedleaf comprize the fourth group and for the most part are more or less intermediate between their parent varieties but show great diversity of character, many selections not closely resembling any well known variety and not intermediate between any two varieties. Some strains approach Zimmer in quality and general appearance of the cured leaves but are in marked contrast while growing in the field.

A comparison of the yields of the hybrids and varieties will show that there has been a general increase in the relative yields of the hybrids during the three years covered by the table. The average increase per acre over Zimmer Spanish for all the hybrids tabulated in 1908 was 189 pounds, in 1909 it rose to 227 pounds and in 1910 reached 405 pounds.

TABLE II. Yields of Hybrids and varieties stated as gains over the yield of Zimmer Spanish Germantown, 1908-10

Pounds per acre

Variety or Hybrid	1908			1909			1910			3 year average	
	No of selections	Av yield of all selections	Yield of best selections	No, of selections	Av yield of all selections	Yield of best selections	No of selections	Av yield of all selections	Yield of best selections	Av yield of all selections	Yield of best selections
Spanish Types											
81	12	182	316	24	209	432	35	258	540	216	429
86	2	201	361	1	26	26	2	100	181	109	183
89	1	412	412	4	368	447	6	434	689	405	516
106	4	108	267	3	139	223	2	200	320	149	270
127	3	206	394	4	290	368	5	316	474	271	412
129	1	134	134	2	20	89	3	103	292	86	172
157	1	86	86	1	111	111	1	499	499	232	232
168	3	135	163	2	200	233	2	286	301	207	232
Average		183	267		169	241		274	412	209	307
Seedleaf Types											
179	1	535	535	2	401	416	2	520	529	485	493
182	2	344	534	3	575	752	5	926	671	482	652
190	1	134	134	1	232	232	1	761	761	376	376
199	2	299	375	8	412	469	9	684	831	465	558
200	2	321	400	5	409	667	3	539	747	423	605
201	1	180	180	2	106	205	1	704	704	330	363
204	1	361	361	4	201	446	4	507	720	356	509
Average		311	360		334	459		606	709	417	508

TABLE II—Continued

Yields of Hybrids and varieties stated as gains over the yields of Zimmer Spanish. Germantown, 1908-10

Variety or Hybrid	1908			1909			1910			3-year average	
	No. of selections	Av. yield of all selections	Yield of best selections	No. of selections	Av. yield of all selections	Yield of best selections	No. of selections	Av. yield of all selections	Yield of best selections	Av. yield of all selections	Yield of best selections
Types Intermediate Between Seedleaf and Spanish											
77	5	274	383	10	259	356	17	393	615	309	451
109	3	159	299	1	384	384	1	424	424	322	369
110	1	186	186	1	281	281	2	544	627	337	365
170	6	135	248	6	205	301	5	428	508	256	352
Average.....		189	279		282	331		447	544	308	385
Hybrids of Cuban and Connecticut Seedleaf											
54	10	84	305	19	211	364	10	275	508	190	392
55	2	119	227	1	—23	—23	1	273	273	123	159
58	1	—257	—257	1	329	329	1	531	531	201	201
72	8	54	273	7	25	280	2	72	215	50	256
75	31	139	496	41	96	385	36	349	740	195	540
Average. ...		28	209		128	267		300	453	152	310
Grand average		189	284		227	321		405	529	274	378
Varieties											
Lauver Spanish.				1	81	81	1	43	43	62	62*
Closeleaf Spanish.....				1	153	153	4	243	468	198	311*
Little Dutch.				1	78	78	3	172	264	125	171*
Connecticut Seedleaf.....	1	—144	—144	1	—74	—74	1	—84	—84	—101	—101
Ohio Seedleaf	2	422	521	5	515	666	6	512	605	483	597
Pennsylvania Seedleaf ..	3	337	439	5	553	580	4	436	484	442	501
Black Seedleaf.				1	553	553	4	514	650	534	602
Pennsylvania Broadleaf..	2			1	730	730	1	553	553	642	642*

*Average for 2 years only, 1909-1910.

If instead of making an average of all the selections of each hybrid we take the average of only the best yielding selections we find the gains over Zimmer Spanish are 284, 321 and 529 pounds per acre respectively for the years 1908, 1909 and 1910.

There have been some exceptions to this increase in yield and numerous irregularities. If the yields of each selection of the various hybrids were separately given these irregularities would be found very marked indeed. This arises from the fact that certain strains of many of these hybrids are not yet fixed types or were not at the time these yields were obtained. This naturally causes great variation of yield within the limits of those hybrids of which a considerable number of selections were planted. Moreover, the different strains vary greatly in their relative adaptability to certain changing factors in environment such as differences in fertility and character of the soil, variations in the weather conditions which occur from year to year, and differences in cultural methods as to rotation, etc.

But notwithstanding the difficulties above outlined in the way of accurate measurement of the relative yielding power of different strains of tobacco, we find most of the hybrids giving consistent and considerable, though varying, gains over Zimmer Spanish regardless of the conditions under which they are grown and also that with many of the hybrids the yields are increasing as the years go by, which is not the case with the old varieties. In this connection see Table III, which shows the 19 hybrids having the best average yield for the three years, 1908-1910, and four varieties, Ohio Seedleaf Pennsylvania Seedleaf, Black Seedleaf and Closeleaf Spanish, arranged in order of their yields in such a way as to show approximately their gains over Zimmer Spanish. In the left hand section of the table they are ranked according to the average yield of all the selections planted, while in the right hand section they are arranged according to the average yield of their best selections. It will be noted that the varieties made approximately the same gains over Zimmer Spanish in 1910 as at the beginning of the period, while most of the hybrids, especially when their best selections are considered, have advanced in yield, this advance being particularly conspicuous between the years 1909 and 1910. We find in the average of all selections that Ohio Seedleaf occupies second place in 1908 and that Pennsyvania Seedleaf and Black Seedleaf are tied for second place in 1909, with Ohio Seedleaf ranking third. In 1910 we find quite a difference in arrangement, no standard variety being found until tenth place is reached which is occupied by Black Seedleaf. Ohio Seedleaf and Pennsylvania Seedleaf rank eleventh and twelfth and Closeleaf Spanish is at the bottom of the whole list.

TABLE III. TOBACCO YIELDS, GERMANTOWN, 1908-1910.
Hybrids and varieties arranged in order of their yields.

Gain over Zimmer Spanish lbs. per acre	Average of all selections			Best selection			Gain over Zimmer Span. lbs. per acre
	1908	1909	1910	1908	1909	1910	
800						Hybrid 199	800
			Hybrid 190		Hybrid 182	Hybrid 190 Hybrid 200 Hybrid 75 Hybrid 204	
700			Hybrid 210			Hybrid 201	700
			Hybrid 199		Hybrid 200 O. Seedleaf	Hybrid 89 Hybrid 182 Blk Seedleaf Hybrid 110 Hybrid 77 O. Seedleaf	
600							600
		Hybrid 182 Blk Seedleaf			Pa. Seedleaf Blk Seedleaf		
	Hybrid 179	Pa. Seedleaf O. Seedleaf	Hybrid 110 Hybrid 200 Hybrid 58 Hybrid 182 Hybrid 179 Blk Seedleaf O. Seedleaf Hybrid 204	Hybrid 179 Hybrid 182 O. Seedleaf		Hybrid 81 Hybrid 179 Hybrid 58 Hybrid 170 Hybrid 54	
500			Hybrid 157	Hybrid 75		Hybrid 157 Pa. Seedleaf Hybrid 127 Closeleaf Sp.	500
			Pa. Seedleaf Hybrid 89	Pa. Seedleaf	Hybrid 199 Hybrid 89 Hybrid 204 Hybrid 81		
	O. Seedleaf Hybrid 89		Hybrid 170 Hybrid 109	Hybrid 89	Hybrid 179	Hybrid 109	
400		Hybrid 199 Hybrid 200		Hybrid 200			400
		Hybrid 179 Hybrid 75 Hybrid 109	Hybrid 77	Hybrid 127 Hybrid 77 Hybrid 199 Hybrid 204	Hybrid 75 Hybrid 109 Hybrid 127 Hybrid 54 Hybrid 77 Hybrid 58		
	Hybrid 204 Hybrid 182 Pa. Seedleaf Hybrid 200	Hybrid 58	Hybrid 75 Hybrid 127	Hybrid 81			
300	Hybrid 199	Hybrid 89		Hybrid 54	Hybrid 170	Hybrid 168	300
		Hybrid 127 Hybrid 110	Hybrid 168	Hybrid 109	Hybrid 110		
	Hybrid 77	Hybrid 77	Hybrid 54 Hybrid 81 Closeleaf Sp.	Hybrid 170	Hybrid 168 Hybrid 190		
		Hybrid 190 Hybrid 54 Hybrid 81 Hybrid 170					
200	Hybrid 127	Hybrid 204			Hybrid 201		200

TABLE III—Continued.

Gain over Zimmer Spanish lbs. per acre	Average of all selections			Best selection			Gain over Zimmer Span. lbs. per acre
	1908	1909	1910	1908	1909	1910	
200	Hybrid 110 Hybrid 81 Hybrid 201 Hybrid 109 Hybrid 75 Hybrid 170 Hybrid 168 Hybrid 190	Hybrid 168 Closeleaf Sp. Hybrid 157 Hybrid 201		Hybrid 110 Hybrid 201 Hybrid 168 Hybrid 190	Closeleaf Sp. Hybrid 157		200
100	Hybrid 157 Hybrid 54			Hybrid 157			100
0	Zim. Span.	Zim. Span. Ct. Seedleaf	Zim. Span. Ct. Seedleaf	Zim. Span.	Zim. Span. Ct. Seedleaf	Zim. Span. Ct. Seedleaf	0
—100	Ct. Seedleaf			Ct. Seedleaf			—100
—200	Hybrid 58			Hybrid 58			—200

When the hybrids and varieties are arranged according to the yields of their best selections, which is more significant from the breeders' standpoint because it better represents the possibility of increased production, we find that for 1908 first place is occupied by hybrid 179 with a gain over Zimmer Spanish of 535 pounds per acre, with hybrid 182 a very close second, and Ohio Seedleaf occupying third place with a gain of 521 pounds. In 1909 hybrid 182 heads the list with an increase of 752 pounds per acre. Then comes hybrid 200 with a gain of 667 pounds per acre; Ohio Seedleaf again occupies third place with a gain of 666 pounds per acre, while next in order come Pennsylvania Seedleaf and Black Seedleaf. In 1910 the highest yield was made by hybrid 199 which exceeded the yield of Zimmer Spanish by 831 pounds per acre. Second in rank for this year (1910) is hybrid 190 with a gain of 761 pounds per acre, followed by hybrids 200, 204 and 201 with gains respectively of 747, 720 and 704 pounds per acre. Following comes hybrid 89 with a gain of 689 pounds per acre, which is a very remarkable increase considering the fact that this hybrid is of Zimmer Spanish type, having leaves shorter than the latter variety, and that two of its three parents have yielded less than Zimmer Spanish which is itself the third parent. Next to hybrid 89 we find hybrid 182 with a gain of

671 pounds, after which we reach the first standard variety in the list, Black Seedleaf, with an increase of 650 pounds per acre which is followed by hybrid 110 with a gain of 627 pounds; this like hybrid 89 is remarkable in having low yielding varieties for its parents, being a cross of Cuban and Zimmer Spanish that produced a greater yield than both parents combined. Next comes hybrid 77 and then Ohio Seedleaf and so on down the line till we reach Closeleaf Spanish which made the third lowest yield exceeding only those of hybrids 109 and 168.

In the further discussion of the hybrids on succeeding pages they are taken up by groups and under each group individual treatment is given to the more prominent members.

Following is a list of the Germantown Hybrids showing cross and parentage of each. In order to trace the lines of descent in those hybrids which are crosses of two other hybrids or of another hybrid and a variety, it will be necessary to determine the cross of such parent hybrids by referring back to the proper place in the table; in case one or both immediate parents are again hybrids, the process must be repeated until all hybrids found in the ancestry are traced back to their parent varieties.

TABLE IV. LIST OF TOBACCO HYBRIDS SHOWING CROSS AND PARENTAGE

Hybrid No.	Cross	Parentage
51	Cub. x Ct. Sd.	1-2 Cuban, 1-2 Connecticut Seedleaf
52	" x "	" " " " "
53	" x "	" " " " "
54	" x "	" " " " "
55	" x "	" " " " "
56	Cub. x Ct. Sd.	1-2 Cuban, 1-2 Connecticut Seedleaf
57	" x "	" " " " "
58	" x "	" " " " "
59	" x "	" " " " "
60	" x "	" " " " "
61	Cub. x Ct. Sd.	1-2 Cuban, 1-2 Connecticut Seedleaf
62	" x "	" " " " "
63	" x "	" " " " "
64	" x "	" " " " "
65	Ct. Sd. x Cub.	" " " " "
66	Ct. Sd. x Cub.	1-2 Cuban, 1-2 Connecticut Seedleaf
67	" x "	" " " " "
68	" x "	" " " " "
69	" x "	" " " " "
70	" x "	" " " " "
71	Ct. Sd. x Cub.	1-2 Cuban, 1-2 Connecticut Seedleaf
72	" x "	" " " " "
73	" x "	" " " " "
74	" x "	" " " " "
75	" x "	" " " " "
76	Ct. Sd. x Cub.	1-2 Cuban, 1-2 Connecticut Seedleaf
77	51 x Zim.	1-2 Zimmer, 1-4 Cuban, 1-4 Connecticut Seedleaf
78	52 x Ohio Seedleaf	1-2 O. Sd., " " " " "
79	52 x Zim.	1-2 Zimmer, " " " " "

Hybrid No.	Cross	Parentage
80	53 x Ohio Seedleaf	1-2 O. Sd., 1-4 Cuban, 1-4 Connecticut Seedleaf
81	54 x Zim.	1-2 Zimmer, " " " " "
82	56 x Zim.	1-2 Zimmer, " " " " "
83	58 x Ohio Seedleaf	1-2 O. Sd., " " " " "
84	60 x Ohio Seedleaf	" " " " " " "
85	61 x Ohio Seedleaf	" " " " " " "
86	62 x Zim.	1-2 Zimmer, 1-4 Cuban, 1-4 Connecticut Seedleaf
87	62 x O. Seedleaf	1-2 O. Sd., " " " " "
88	63 x O. Seedleaf	1-2 O. Sd , " " " " "
89	64 x Zim.	1-2 Zimmer, " " " " "
90	65 x Zim.	" " " " " " "
91	66 x O. Seedleaf	1-2 O. Sd., 1-4 Cuban, 1-4 Connecticut Seedleaf
92	67 x O. Seedleaf	1-2 O. Sd , " " " " "
93	68 x Zim.	1-2 Zimmer, " " " " "
94	69 x O. Seedleaf	1-2 O. Sd., " " " " "
95	69 x O. Seedleaf	1-2 O. Sd., " " " " "
96	70 x O. Seedleaf	1-2 O. Sd., 1-4 Cuban, 1-4 Connecticut Seedleaf
97	71 x O. Seedleaf	" " " " " " "
98	72 x O. Seedleaf	" " " " " " "
99	73 x Zim.	1-2 Zimmer, " " " " "
100	75 x Zim.	1-2 Zimmer, " " " " "
101	51 x Zim.	1-2 Zimmer, 1-4 Cuban, 1-4 Connecticut Seedleaf
102	71 x Zim.	" " " " " " "
103	Zim. x 71	" " " " " " "
104	Zim. x 66	" " " " " " "
105	Zim. x 61	" " " " " " "
106	Zim. x 61	1-2 Zimmer, 1-4 Cuban, 1-4 Connecticut Seedleaf
107	Zim. x 52	" " " " " " "
108	Zim. x 52	" " " " " " "
109	Zim. x O. Sd.	" " 1-2 Ohio Seedleaf
110	Zim. x Cuban	" " 1-2 Cuban.
111	54 x 75	1-2 Cuban, 1-2 Connecticut Seedleaf
112	54 x 55	" " " " "
113	55 x 106	1-4 Zim., 3-8 Cuban, 3-8 Connecticut Seedleaf
114	58 x 55	1-2 Cuban, 1-2 Connecticut Seedleaf
115	75 x 55	" " " " "
116	75 x 104	1-4 Zim., 3-8 Cuban, 3-8 Connecticut Seedleaf
117	76 x Zim.	1-2 Zim., 1-4 Cuban, 1-4 Connecticut Seedleaf
118	76 x 61	1-2 Cuban, 1-2 Connecticut Seedleaf
119	76 x Cuban	3-4 " 1-4 " "
120	76 x O. Seedleaf	1-2 O. Seedleaf, 1-4 Cuban, 1-4 Ct. Seedleaf
121	77 x Zim.	3-4 Zim., 1-8 Cuban, 1-8 Ct. Seedleaf
122	78 x 109	1-2 O. Sd., 1-4 Zim., 1-8 Cuban, 1-8 Ct. Seedleaf
123	78 x Zim.	1-2 Zim., 1-4 O. Sd., " " " " "
124	78 x 75	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 O. Seedleaf
125	79 x Zim.	3-4 Zim , 1-8 Cuban, 1-8 Ct. Seedleaf
126	79 x 106	1-2 Zim., 1-4 Cuban, 1-4 Ct. Seedleaf
127	80 x 75	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 O. Seedleaf
128	80 x 106	1-4 Zim., 1-4 Cuban, 1-4 Ct. Seedleaf, 1-4 O. Seedleaf
129	80 x 79	" " " " " " " "
130	80 x 59	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 O. Seedleaf
131	83 x 110	3-8 Cuban, 1-4 Zim., 1-4 O. Seedleaf, 1-8 Ct. Sd.
132	83 x O. Seedleaf	3-4 O. Seedleaf, 1-8 Cuban, 1-8 Ct. Seedleaf
133	83 x Cuban	5-8 Cuban, 1-4 O. Seedleaf, 1-8 Ct. Seedleaf
134	84 x 58	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 O. Seedleaf
135	84 x O. Seedleaf	3-4 O. Seedleaf, 1-8 Cuban, 1-8 Ct. Seedleaf
136	84 x 106	1-4 Zim., 1-4 Cuban, 1-4 Ct. Seedleaf, 1-4 O. Seedleaf
137	85 x 110	3-8 Cuban, 1-4 Zim., 1-4 O. Seedleaf, 1-8 Ct. Seedleaf
138	88 x Zim.	1-2 Zim., 1-4 O. Seedleaf, 1-8 Cuban, 1-8 Ct. Seedleaf
139	107 x Zim.	3-4 Zim., 1-8 Cuban, 1-8 Ct. Seedleaf
140	109 x 109	1-2 Zim., 1-2 O. Seedleaf
141	109 x 109	1-2 Zim., 1-2 O. Seedleaf
142	109 x 61	1-4 Zim., 1-4 Cuban, 1-4 Ct. Seedleaf, 1-4 O. Sd.

Hybrid No.	Cross	Parentage
143	109 x O. Seedleaf	3-4 O. Seedleaf, 1-4 Zim.
144	109 x Zim.	3-4 Zim., 1-4 O. Seedleaf
145	109 x Zim.	3-4 Zim., 1-4 O. Seedleaf
146	109 x 106	1-2 Zim., 1-4 O. Seedleaf, 1-8 Cuban, 1-8 Ct. Sd.
147	109 x 77	1-2 Zim., 1-4 O. Seedleaf, 1-8 Cuban, 1-8 Ct. Sd.
148	109 x O. Seedleaf	3-4 O. Seedleaf, 1-4 Zim.
149	109 x Zim.	3-4 Zim., 1-4 O. Seedleaf
150	109 x Zim.	3-4 Zim., 1-4 O. Seedleaf
151	110 x Cuban	3-4 Cuban, 1-4 Zimmer.
152	Zimmer x 77	3-4 Zimmer, 1-8 Cuban, 1-8 Ct. Seedleaf
153	Zimmer x 104	3-4 " 1-8 Cuban, 1-8 Ct. Seedleaf
154	Zimmer x 109	3-4 " 1-4 O. Seedleaf
155	Zimmer x 104	3-4 " 1-8 Cuban, 1-8 Ct. Seedleaf
156	Zimmer x 83	1-2 " 1-4 O. Seedleaf, 1-8 Cuban, 1-8 Ct. Sd.
157	Zimmer x 78	1-2 " 1-4 O. Seedleaf, 1-8 Cuban, 1-8 Ct. Sd.
158	Zimmer x 106	3-4 " 1-8 Cuban, 1-8 Ct. Seedleaf
159	Zimmer x 77	" " " " " "
160	Zimmer x 86	" " " " " "
161	Zimmer x 79	" " " " " "
162	Zimmer x 109	3-4 " 1-4 O. Seedleaf
163	Zimmer x 77	3-4 " 1-8 Cuban, 1-8 Ct. Seedleaf
164	Zimmer x 109	3-4 " 1-4 O. Seedleaf
165	Zimmer x 109	3-4 " 1-4 O. Seedleaf
166	Zimmer x 109	3-4 Zimmer, 1-4 O. Seedleaf
167	Zimmer x 106	3-4 Zimmer, 1-8 Cuban, 1-8 Ct. Seedleaf
168	Zimmer x (?)	
169	Zimmer x O. Sd.	1-2 Zimmer, 1-2 O. Seedleaf
170	Zimmer x O. Sd.	1-2 Zimmer, 1-2 O. Seedleaf
171	Zimmer x 105	3-4 Zimmer, 1-8 Cuban, 1-8 Ct. Seedleaf
172	77 x O. Seedleaf.	1-2 O. Seedleaf, 1-4 Zim., 1-8 Cuban, 1-8 Ct. Sd.
173	71 x 71	1-2 Cuban, 1-2 Ct. Seedleaf
174	71 x 71	1-2 Cuban, 1-2 Ct. Seedleaf
175	Unknown	Unknown
176	Pa. Sd. x Vuelta	1-2 Pa. Sd., 1-2 Vuelta
177	Pa. Sd. x (?)	1-2 Pa. Sd., 1-2
178	Pa. Sd. x Cooley*	1-2 Pa. Sd., 1-4 Ct. Havana, 1-4 Sumatra
179	Pa. Sd. x 4 Sucker	1-2 Pa. Sd., 1-2 4 Sucker
180	Pa. Sd. x Ct. Hav.	1-2 P. Sd., 1-2 Ct. Havana
181	Pa. Sd. x 110	1-2 Pa. Sd., 1-4 Zimmer, 1-4 Cuban
182	Pa. Sd. x Black Sd.	1-2 Pa. Sd., 1-2 Black Seedleaf
183	Pa. Sd. x Ct. Broad.	1-2 Pa. Sd., 1-2 Ct. Broadleaf
184	Pa. Sd. x 167	1-2 Pa. Sd., 3-8 Zim., 1-16 Cuban, 1-16 Ct. Seedleaf
185	Pa. Sd. x 151	1-2 Pa. Sd., 1-4 Zimmer, 1-4 Cuban
186	Pa. Sd. x Big Gra.	1-2 Pa. Sd., 1-2 Big Graham
187	Pa. Sd. x O. Sd.	1-2 Pa. Sd., 1-2 O. Seedleaf
188	Pa. Sd. x Sumatra	1-2 Pa. Sd., 1-2 Sumatra
189	Pa. Sd. x Zimmer	1-2 Zimmer, 1-2 Pa. Seedleaf
190	Pa. Sd. x Vuelta	1-2 Pa. Seedleaf, 1-2 Vuelta
191	Pa. Sd. x Zimmer	1-2 Zimmer, 1-2 Pa. Seedleaf
192	O. Sd. x Vuelta	1-2 O. Seedleaf, 1-2 Vuelta
193	Vuelta x Cuban	1-2 Cuban, 1-2 Vuelta
194	Vuelta x Big Gra.	1-2 Vuelta, 1-2 Big Graham
195	Vuelta x Black Sd.	1-2 Vuelta, 1-2 Black Seedleaf
196	Vuelta x 75	1-2 Vuelta, 1-4 Cuban, 1-4 Ct. Seedleaf
197	Vuelta x 83	1-2 Vuelta, 1-4 O. Sd., 1-8 Cuban, 1-8 Ct. Seedleaf
198	Cuban x 106	5-8 Cuban, 1-4 Zimmer, 1-8 Ct. Seedleaf
199	O. Sd. x Big Gra.	1-2 O. Seedleaf, 1-2 Big Graham
200	O. Sd. x Little Gra.	1-2 O. Seedleaf, 1-2 Little Graham
201	Cooley x Black Sd.	1-2 Black Sd., 1-4 Ct. Havana, 1-4 Sumatra
202	Black Sd. x Ct. Hav.	1-2 Black Sd., 1-2 Ct. Havana
203	Black Sd. x Big Gra.	1-2 Black Seedleaf, 1-2 Big Graham

* Cooley Hybrid is a cross of Ct. Havana and Sumatra made by A. D. Shamel in Connecticut.

Hybrid No.	Cross	Parentage
204	Black Sd. x 83	1-2 Black Sd., 1-4 O. Sd., 1-8 Cuban, 1-8 Ct. Sd
205	Big Gra. x 110	1-2 Big Graham, 1-4 Zimmer, 1-4 Cuban
206	Big Gra. x Pa. Sd.	1-2 Pa. Sd., 1-2 Big Graham
207	Big Gra. x 75	1-2 Big Graham, 1-4 Cuban, 1-4 Ct. Seedleaf
208	Big Gra. x Zimmer	1-2 Zimmer, 1-2 Big Graham
209	Zimmer x 75	1-2 Zimmer, 1-4 Cuban, 1-4 Ct. Seedleaf
210	Zimmer x 4 Sucker	1-2 Zimmer, 1-2 4 Sucker
211	Ct. Hav. x 4 Sucker	1-2 Ct. Havana, 1-2 4 Sucker
212	Pa. Sd. x Sumatra	1-2 Pa. Seedleaf, 1-2 Sumatra
213	O. Sd. x Ct. Havana	1-2 O. Seedleaf, 1-2 Connecticut Havana
214	O. Sd. x Cooley	1-2 O. Sd., 1-4 Ct. Havana, 1-4 Sumatra
215	O. Sd. x Sumatra	1-2 O. Seedleaf, 1-2 Sumatra
216	Zimmer x Vuelta	1-2 Zimmer, 1-2 Vuelta
217	Vuelta x Zimmer	1-2 Zimmer, 1-2 Vuelta
218	Vuelta x Ct. Havana	1-2 Vuelta, 1-2 Ct. Havana
219	Vuelta x Pa. Sd.	1-2 Pa. Seedleaf, 1-2 Vuelta
220	Vuelta x Ct. Broad.	1-2 Vuelta, 1-2 Ct. Broadleaf
221	Vuelta x Cooley	1-2 Vuelta, 1-4 Ct. Havana, 1-4 Sumatra
222	Ct. Havana x Zim.	1-2 Zimmer, 1-2 Ct. Havana
223	Zimmer x 106	3-4 Zimmer, 1-8 Cuban, 1-8 Ct. Seedleaf
224	106 x Zimmer	3-4 Zimmer, 1-8 Cuban, 1-8 Ct. Seedleaf
225	Zimmer x 75	1-2 Zimmer, 1-4 Cuban, 1-4 Ct. Seedleaf
226	75 x Zimmer	1-2 Zimmer, 1-4 Cuban, 1-4 Ct. Seedleaf
227	Zimmer x 75	1-2 Zimmer, 1-4 Cuban, 1-4 Ct. Seedleaf
228	75 x Zimmer	1-2 Zimmer, 1-4 Cuban, 1-4 Ct. Seedleaf
229	75 x 81	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
230	81 x 75	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
231	75 x 72	1-2 Cuban, 1-2 Ct. Seedleaf
232	72 x 75	1-2 Cuban, 1-2 Ct. Seedleaf
233	75 x 106	3-8 Cuban, 3-8 Ct. Seedleaf, 1 4 Zimmer
234	106 x 75	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
235	72 x 81	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
236	81 x 72	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
237	81 x 106	1-2 Zimmer, 1-4 Cuban, 1-4 Ct. Seedleaf
238	106 x 81	1-2 Zimmer, 1-4 Cuban, 1-4 Ct. Seedleaf
239	54 x 75	1-2 Cuban, 1-2 Ct. Seedleaf
240	54 x 77	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
241	54 x 77	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
242	54 x 106	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
243	54 x Cuban	3-4 Cuban, 1-4 Ct. Seedleaf
244	75 x 75	1-2 Cuban, 1-2 Ct. Seedleaf
245	77 x 75	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
246	77 x 75	3-8 Cuban, 3-8 Ct. Seedleaf, 1-4 Zimmer
247	77 x (?)	
248	81 x 81	1-2 Zimmer, 1-4 Cuban, 1-4 Ct. Seedleaf
249	81 x 214	1-4 Zim., 1-4 O. Sd., 1-8 Cuban, 1-8 Ct. Sd., 1-8 Ct. Havana, 1-8 Sumatra
250	81 x 214	1-4 Zim., 1-4 O. Sd., 1-8 Cuban, 1-8 Ct. Sd. 1-8 Ct. Havana, 1-8 Sumatra
251	81 x 214	1-4 Zim., 1-4 O. Sd., 1-8 Cuban, 1-8 Ct. Sd., 1-8 Ct. Havana, 1-8 Sumatra
252	81 x Cooley	1-4 Zim., 1-4 Ct. Hav., 1-4 Sum., 1-8 Cub., 1-8 Ct. Sd.
253	81 x O. Seedleaf	1-2 O. Sd., 1-3 Zim., 1-8 Cuban, 1-8 Ct. Seedleaf
254	81 x O. Seedleaf	1-2 O. Sd., 1-4 Zimmer, 1-8 Cuban, 1-8 Ct. Seedleaf
255	81 x O. Seedleaf	1-2 O. Sd., 1-4 Zimmer, 1-8 Cuban, 1-8 Ct. Seedleaf
256	81 x Pa. Sd.	1-2 Pa. Sd., 1-4 Zim., 1-8 Cuban, 1-8 Ct. Seedleaf
257	199 x 54	1-4 Cub., 1-4 Ct. Sd., 1-4 O. Sd., 1-4 Big Graham
258	199 x 77	1-4 Zim., 1-4 O. Sd., 1-4 Big Gra., 1-8 Cub., 1-8 Ct. Sd.
259	199 x 81	1-4 Zim., 1-4 O. Sd., 1-4 Big Gra., 1-8 Cub., 1-8 Ct. Sd.
260	199 x 181	1-4 Pa. Sd., 1-4 O. Sd., 1-4 Big Gra., 1-8 Zim., 1-8 Cub.

Hybrid No.	Cross	Parentage
261	199 x 181	1-4 Pa. Sd., 1-4 O. Sd., 1-4 Big Gra., 1-8 Zim., 1-8 Cub.
262	199 x 185	1-4 Pa. Sd., 1-4 O. Sd.. 1-4 Big Gra., 3-16 Cub., 1-16 Zim.
263	214 x O. Sd.	3-4 O. Sd.. 1-8 Ct. Hav., 1-8 Sumatra
264	O. Sd. x 214	3-4 O. Sd., 1-8 Ct. Hav., 1-8 Sumatra
265	O. Sd. x Cooley	1-2 O. Sd., 1-4 Ct. Hav., 1-4 Sumatra
266	O. Sd. x Cooley	1-2 O. Sd., 1-4 Ct. Hav., 1-4 Sumatra
267	O. Sd. x (?)	1-2 O. Sd., 1-2 (?) (?)
268	Cooley x 75	1-4 Cub., 1-4 Ct. Sd., 1-4 Ct. Hav., 1-4 Sumatra
269	Cooley x 182	1-4 Pa. Sd., 1-4 Black Sd., 1-4 Ct. Hav., 1-4 Sumatra
270	Cooley x 200	1-4 O. Sd,, 1-4 Lit. Gra., 1-4 Ct. Hav., 1-4 Sumatra
271	Cooley x 214	3-8 Ct. Hav., 3-8 Sumatra, 1-4 O. Sd.
272	Cooley x 214	3-8 Ct. Hav., 3-8 Sumatra, 1-4 O. Sd.
273	Cooley x O. Sd.	1-2 O. Sd., 1-4 Ct. Hav., 1-4 Sumatra
274	Cooley x O. Sd.	1-2 O. Sd., 1-4 Ct. Hav., 1-4 Sumatra
275	81 x Zim.	3-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
276	Cooley x O. Sd.	1-2 O. Sd., 1-4 Ct. Hav., 1-4 Sumatra
277	127 x 257	5-16 Cub., 5-16 Ct. Sd., 1-4 O. Sd., 1-8 Big Graham
278	75 x 81	3-8 Cub., 3-8 Ct. Sd., 1-4 Zim.
279	75 x 81	3-8 Cub., 3-8 Ct. Sd., 1-4 Zim.
280	75 x 127	7-16 Cub., 7-16 Ct. Sd., 1-8 O. Sd.
281	75 x 179	1-4 Cub., 1-4 Ct. Sd., 1-4 Pa. Sd., 1-4 4 Sucker
282	75 x Zim.	1-2 Zim., 1-4 Cub., 1-4 Ct. Sd.
283	75 x Zim.	1-2 Zim., 1-4 Cub., 1-4 Ct. Sd.
284	75 x Closeleaf Sp.	1-2 Closeleaf Span., 1-4 Cub., 1-4 Ct. Sd.
285	75 x Big Cub.	1-2 Big Cub., 1-4 Cub., 1-4 Ct. Sd.
286	75 x Black Sd.	1-2 Black Sd., 1-4 Cub., 1-4 Ct. Sd.
287	77 x 75	3-8 Cub., 3-8 Ct. Sd., 1-4 Zim.
288	77 x 81	1-2 Zim., 1-4 Cub., 1-4 Ct. Sd.
289	77 x Closeleaf Sp	1-2 Close. Sp., 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
290	81 x 75	3-8 Cub., 3-8 Ct. Sd., 1-4 Zim.
291	81 x 179	1-4 Pa. Sd., 1-4 4 Suck., 1-4 Zim., 1-8, Cub., 1-8 Ct. Sd.
292	81 x Zim.	3-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
293	81 x Dutch	1-2 Dutch, 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
294	201 x 127	1-4 Blk. Sd., 3-16 Cub., 3-16 Ct. Sd., 1-8 O. Sd., 1-8 Ct. Hav., 1-8 Sumatra
295	Closeleaf Sp. x 54	1-2 Closeleaf Sp., 1-4 Cub., 1-4 Ct. Sd.
296	Closeleaf Sp. x 75	1-2 Closeleaf Sp., 1-4 Cub., 1-4 Ct. Sd.
297	Closeleaf Sp. x 77	1-2 Closeleaf Span., 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
298	Closeleaf Sp. x 81	1-2 Closeleaf Span., 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
299	Closeleaf Sp. x 127	1-2 Close. Sp., 3-16 Cub., 3-16, Ct. Sd., 1-8 O. Sd.
300	Closeleaf Sp. x Zim.	1-2 Zim., 1-2 Closeleaf Span.
301	Close. Sp. x Big. Cub.	1-2 Closeleaf Span., 1-2 Big Cub.
302	Big. Cub. x 77	1-2 Big Cub., 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
303	Big. Cub. x Zim.	1-2 Zim., 1-2 Big Cub.
304	Big. Cub. x Close. Sp.	1-2 Closeleaf Span., 1-2 Big Cub
305	O. Sd. x Cloself. Sp.	1-2 O. Sd., 1-2 Closeleaf Span.
306	O. Sd. x Big. Cub.	1-2 O. Sd., 1-2 Big Cub.
307	O. Sd. x Dutch	1-2 O. Sd., 1-2 Dutch
308	O. Sd. x White Bur.	1-2 O. Sd., 1-2 White Burley
309	Black Sd. x 77	1-2 Black Sd., 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
310	(?) x (?)	(?) (?)
311	(?) x 54	1-4 Cub., 1-4 Ct. Sd., 1-2 (?) (?)
312	(?) x 81	1-4 Zim., 1-8 Cub., 1-8 Ct. Sd., 1-2 (?) (?)
313	(?) x 179	1-4 Pa. Sd., 1-4 4 Sucker, 1-2 (?) (?)
314	(?) x O. Sd.	1-2 O. Sd., 1-2 (?) (?)
315	75 x 81	3-8 Cub., 3-8 Ct. Sd., 1-4 Zim.
316	75 x 81	3-8 Cub., 3-8 Ct. Sd., 1-4 Zim.
317	75 x 81	3-8 Cub., 3-8 Ct. Sd., 1-4 Zim.
318	81 x 75	3-8 Cub.. 3-8 Ct. Sd., 1-4 Zim.
319	75 x 110	1-4 Zim., 1-4 Ct. Sd., 1-2 Cub.

Hybrid No.	Cross	Parentage
320	75 x 157	5-16 Cub., 5-16 Ct. Sd , 1-4 Zim., 1-8 O. Sd.
321	157 x 75	5-16 Cub., 5-16 Ct. Sd., 1-4 Zim , 1-8 O. Sd.
322	157 x 75	5-16 Cub., 5-16 Ct. Sd, 1-4 Zim., 1-8 O. Sd.
323	75 x 204	5-16 Cub., 5-16 Ct. Sd , 1-4 Black Sd., 1-8 O. Sd.
324	75 x 238	3-8 Cub., 3-8 Ct. Sd., 1-4 Zim.
325	238 x 75	3-8 Cub., 3-8 Ct. Sd., 1-4 Zim.
326	75 x 264	3-8 O. Sd., 1-4 Cub., 1-4 Ct. Sd., 1-16 Ct. Hav., 1-16 Sumatra
327	75 x Zim.	1-2 Zim., 1-4 Cub., 1-4 Ct. Sd.
328	75 x Dutch	1-2 Dutch, 1-4 Cub., 1-4 Ct. Sd.
329	75 x Dutch	1-2 Dutch, 1-4 Cub., 1-4 Ct. Sd.
330	75 x Dutch	1-2 Dutch, 1-4 Cub., 1-4 Ct. Sd.
331	81 x 157	1-2 Zim., 3 16 Cub., 3-16 Ct. Sd., 1-8 O. Sd.
332	157 x 81	1-2 Zim., 3-16 Cub., 3-16 Ct. Sd., 1-8 O. Sd.
333	238 x 81	1-2 Zim., 1-4 Cub., 1-4 Ct., Sd.
334	238 x 81	1-2 Zim., 1-4 Cub., 1-4 Ct. Sd.
335	81 x 264	3-8 O. Sd., 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd., 1-16 Ct. Hav., 1-16 Sumatra
336	81 x Zim.	3-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
337	81 x Dutch	1-2 Dutch, 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd.
338	110 x 157	1-2 Zim., 5-16 Cub., 1-8 O. Sd., 1-16 Ct. Sd.
339	238 x 110	1-2 Zim., 3-8 Cub., 1-8 Ct. Sd.
340	110 x Zim.	3-4 Zim,, 1-4 Cub.
341	157 x 129	3-8 Zim., 3-16 Cub., 3-16 Ct. Sd., 1-4 O. Sd.
342	157 x 204	1-4 Zim., 1-4 O. Sd., 1-4 Black Sd., 1-8 Cub., 1-8 Ct. Sd.
343	204 x 157	1-4 Zim., 1-4 O. Sd., 1-4 Black Sd., 1-8 Cub.. 1-8 Ct. Sd.
344	157 x 264	1-2 O. Sd., 1-4 Zim., 1-16 Cub., 1-16 Ct. Sd., 1-16 Ct. Hav., 1-16 Sumatra
345	157 x Zim.	3-4 Zim., 1-8 O. Sd., 1-16 Cub., 1-16 Ct. Sd.
346	157 x Big. Cub.	1-2 Big Cub., 1-4 Zim., 1-8 O. Sd., 1-16 Cub., 1-16 Ct. Sd.
347	204 x 238	1-4 Zim., 1-4 Black Sd., 3-16 Cub., 3-16 Ct. Sd., 1-8 O. Sd.
348	204 x 264	1-2 O. Sd., 1-4 Black Sd., 1-16 Cub., 1-16 Ct. Sd., 1-16 Ct. Hav., 1-16 Sumatra
349	238 x 264	3-8 O. Sd., 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd., 1-16 Ct. Hav., 1-16 Sumatra
350	238 x Big. Cub.	1-2 Big Cub., 1-4 Zim., 1-8 Cub., 1-8 Ct. Sd.

Date made:—51-76, 1903; 77-110, 1904; 111-175, 1905; 176-222, 1906; 223-238, 1907; 239-277, 1908; 278-314, 1909; 315-350, 1910.

HYBRIDS OF CUBAN AND CONNECTICUT SEEDLEAF

As already stated the breeding work was started by making twenty-six distinct hybrids between Cuban and Connecticut Seedleaf. This work was done in 1903 and the first crop grown from hybrid seed was produced the following year. In this first generation all the hybrids of this group were intermediate between their two parent varieties in general appearance although in certain individiual characters they rather closely approached one or the other parent: For instance, in character of stalk they resembled Cuban much more closely than Connecticut Seedleaf. The plants of each hybrid were quite uniform but there were rather marked differences between the various hybrids, due in all probability to differences in their Cuban parents, for this variety when grown in this climate breaks up in a manner analagous to the variation observed in hybrids. In vigor of growth these hybrids were much superior to their parental average and were perhaps fully as productive as their larger parent, Connecticut Seedleaf.

Fifteen of the most vigorous of these hybrids were selected for further testing and the seed from a number of the best plants of each lumped together and sown in the spring of 1905. From these seedings duplicate plantings were made and the yields accurately determined. The results this year, so far as the general appearance of the plots or the yields obtained are concerned, were discouraging. None of the hybrids made satisfactory yields, all of them producing less than Zimmer Spanish. The variation in all of these hybrids was extreme. Many plants were worthless to the last degree and some were so small and spreading in habit of growth and bore leaves so narrow that before blooming time even an expert could hardly have recognized them as tobacco plants. However, here and there a good plant appeared and these were saved to carry forward the breeding work, and has resulted in the production of several very productive new varieties of tobacco.

The discussion of this group of hybrids can best be continued by taking up individually several of the more important hybrids, as the variation in the second generation was so great that no two plants of sufficient individual merit to warrant propagation, bore any considerable resemblance to each other. The hybrids in this group are numbered from 51 to 76. Only five of them are being grown and the further discussion will be confined to these.

HYBRID 54

Hybrid 54 in the first generation was the latest of the group. In the second generation a tall, late plant with semi-erect leaves was discovered. Considered apart from its environment this plant seemed to possess no particular merit, but

as it grew under very bad conditions it was deemed worthy of trial. The next year a plot planted of its progeny produced some surprisingly fine plants and as a whole was fairly uniform and quite productive. Seed plant 54-202 (1906) may be taken as a typical representative of this plot. It was very tall with thirty medium-sized, semi-erect leaves of medium to light green color. The only serious objection was the late maturity as it did not bloom until in September, though set out in good time. The seed, however, ripened promptly and the leaves cured rapidly, seemed to be of good quality and weighed 9.25 ounces.

Quite a number of additional seed plants were saved and propagated individually the next year. No marked breaking up of type has been observed in any of their descendants, although some variation has been noted. This strain of tobacco does very well in normal seasons but fires rather badly on certain types of soil during very hot, dry weather which, together with its late maturity, constitutes its chief faults. It also requires higher tiers in the curing shed than are common to hang the tobacco when grown under good conditions. Its yield in comparison with those of Zimmer Spanish and its parent varieties are shown in the accompanying table.

This hybrid will probably never be extensively grown as better ones have been developed. It is worthy of note that one of the very best Spanish type hybrids yet developed by the Station (Hybrid 81) is a cross of Zimmer Spanish by Hybrid 54. Certain other hybrids of later origin having Hybrid 54 for one parent are also under investigation and may prove valuable.

TABLE V. Statistics of Hybrid 54, grown at Germantown Test Farm, 1904-1910. Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 54			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 54			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1904	1,093	....	....	520	910	715	913	378	....	180	....
1905	688	...	....	596	900	748	846	—60	...	—158	....
1906	1,216	1,026	1,506	598	1,187	893	1,206	323	613	10	300
1907	1,247	929	1,407	595	1,200	898	1,044	347	509	203	363
1908	1,034	601	1,255	553	806	680	950	354	575	84	305
1909	1,141	956	1,294	462	856	659	930	481	634	211	364
1910	1,386	1,204	1,619	633	1,027	830	1 111	556	779	275	508
3-yr. av. 1908-1910	1,187	920	1 389	549	896	723	997	464	663	190	392

HYBRID 58

Originally this was one of the most productive hybrids of the Cuban-Connecticut Seedleaf group. Quite a number of selections were carried for several years but most of them were gradually dropped as certain strains of other hybrids assumed greater importance. In 1910 but a single plant was used to propagate this hybrid. The resulting yield was very good and the quality fine. In most characters the tobacco approached seedleaf more nearly than any other class of tobacco. The leaves are long and rather drooping but resemble

Cuban in being relatively broad, especially near the tips. The yield for this year amounted to 1,642 pounds per acre, a gain of 531 pounds over the yield of Zimmer Spanish. The uniformity was good and two seed plants were chosen to carry forward the breeding in 1911. These two selections showed no apparent difference in the field, indicating that a fixed type had been obtained. Both made a remarkably vigorous growth, but a short time previous to ripening both selections rusted very badly, a defect never before noted in this hybrid and seldom occurring with any variety under the soil conditions prevailing at the Test Farm. It seems that the fine seed plant obtained in 1909 which produced such a bountiful crop of fine tobacco in 1910 possessed a fatal weakness in this direction but did not show this undesirable tendency that year, owing to weather conditions which were not favorable to the development of rust. Notwithstanding its fine record in 1910 this hybrid will in all probability have to be discarded, for every plant was very badly rusted while no rust at all was exhibited by any of the many other hybrids grown under similar conditions. The yields to date are shown in Table VI.

TABLE VI. Statistics of Hybrid 58, grown at Germantown Test Farm, 1904-1910 Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 58			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 58			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1904	1,098	...	....	520	910	715	913	383	....	185	....
1905	620	....	....	596	900	748	846	—128	....	—226	....
1906	916	540	1,233	598	1,187	893	1,206	23	340	—290	27
1907	1,234	1,111	1,357	595	1,200	898	1,044	336	459	190	313
1908	693	693	693	553	806	680	950	13	13	—257	—257
1909	1,259	1,259	1,259	462	856	659	930	600	600	329	329
1910	1,642	1,642	1,642	633	1,027	830	1,111	812	812	531	531
3-yr. av. 1908-1910	1,198	828	1,369	549	896	723	997	475	475	201	201

HYBRID 69

Hybrid 69 has a history similar to that of the hybrids already discussed. After several generations of trial all selections were discarded except a couple of tall types intermediate in habit of growth between Cuban and Connecticut Seedleaf. These give considerable trouble in the removal of suckers but in this respect show much improvement over the earlier generations of the same sort. The yields of this hybrid have been moderate with fair to good quality. See Table VII. This hybrid has been dropped to make room for something better.

TABLE VII.* Statisticts of Hybrid 69, grown at Germantown Test Farm, 1904-1909. Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 69			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 69			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1904	1,073	....	....	520	910	715	913	358	....	160	....
1905	776	....	....	596	900	748	846	28	....	—70	....
1906	1,213	1,141	1,281	598	1,187	893	1,206	320	388	7	75
1907	1,109	847	1,235	595	1,200	898	1,044	211	337	65	191
1908	1,096	1,033	1,237	553	806	680	950	437	578	166	307
1909	1,048	1,001	1,088	462	856	659	930	389	429	118	158
3-yr. av. 1907-1909	1,084	960	1,187	537	954	746	975	346	448	116	219

HYBRID 72

In the first generation number 72 was the stockiest hybrid of the entire group and had the shortest internodes. The upper leaves were long and narrow in proportion to their width, a peculiarity which has characterized nearly all the selections obtained from this hybrid. Like other hybrids of the same parentage number 72 broke up into a large number of types in the second generation. In the third generation quite a number of seed plants were propagated individually and in addition, several lots of seed made up from several plants more or less closely resembling each other were sown. The progeny of several of these selections, particularly plant 119, produced very good yields of fine quality tobacco. The suckers, however, were qnite troublesome in all the selections.

In the fourth generation, grown in 1905, several selections produced tobacco of very fine appearance and smoking quality. In fact, the progeny of seed plant 224 was pronounced by tobacco experts at Washington, D. C., where the smoking test was conducted, to be the finest Ohio grown cigar filler tobacco they had ever seen. Another point in its favor was its comparative freedom from suckers, in which respect it was very much superior to any other strain of this hybrid and better than nearly all other selections of the whole group of Cuban-Connecticut Seedleaf hybrids. The yield, however, was but moderate, being only a little greater than that of Zimmer Spanish.

The cigars made from this selection of Hybrid 72 found high favor with nearly every smoker who gave them a trial and it was hoped that this strain would prove to be a valuable new variety of tobacco but our efforts to maintain the superior smoking quality and appearance in later generations were futile, as were also the attempts to improve the yield. In spite of all that could be done both yield and quaility have deteriorated. Certain other selections of Hybrid 72 made a much better yield in the fourth generation than did seed plant 224 and some of them also possessed good quality but suckered so badly as to make them undesirable from the grower's standpoint. These strains, like selection 224, have been refractory in our efforts to improve them. It would seem that degeneration is written in large letters in the hereditary makeup of this hybrid; even when used as one of the parents of an intercross with Hybrid 81. it seemed

to project this fatal influence into its offspring which behaved like their paternal ancestor, flourishing for a couple of generations and then in spite of all that could be done, rapidly degenerating. This hybrid, therefore, has been one of the big disappointments of our breeding work. Just what explanation could be advanced to account for its peculiar behavior is not clear. The yields of Hybrid 72 are given in Table VIII.

TABLE VIII. Statistics of Hybrid 72, grown at Germantown Test Farm, 1904-1910. Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 72			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 72			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1904	1,108	...	....	520	910	715	913	393	.. .	195	....
1905	766	...	....	596	900	748	846	18	....	−80	....
1906	1,482	966	1,489	598	1,187	893	1,206	589	596	276	283
1907	996	818	1,209	595	1,200	898	1,044	98	311	−48	165
1908	1.004	841	1,223	553	806	680	950	324	543	54	273
1909	955	732	1,210	462	856	659	930	296	551	25	280
1910	1,183	1,039	1 326	633	1,027	830	1,111	353	496	72	215
3-yr. av. 1908-1910	1,047	871	1,253	549	896	723	997	324	530	50	256

HYBRID 75

Hybrid 75 as judged by the measurements of the plants and their leaves in the first generation was slightly superior to all other hybrids of the Cuban-Connecticut Seedleaf group. Quite a number of plants were saved for seed which was mixed together before sowing. From the plants produced by this seed, duplicate plots were grown in 1905. These made a very poor showing, many plants being extremely poor, many others indifferent and a few rather promising. About ten of the best plants were propagated individually the next year and the result was a wide range in yield, quality and field characters. The descendants of seed plant 119 were of fairly upright habit of growth and from the progeny of this plant was selected a strain somewhat resembling Zimmer Spanish. This strain while quite distinct from the latter variety is remembered as the only one among the many hundred variations derived from crosses between the traditional parents of Zimmer Spanish which bore any resemblance to the above named variety.

Seed plant 155 was a rather tall plant with smooth leaves. Its offspring in 1906 were fairly uniform and rather productive. The stalks were very tall, the leaves far apart and the suckers very troublesome. This strain was continued a couple of years and then dropped to make room for more promising types.

Seed plant 154 was a plant of medium height with short internodes and dark green, semi-erect leaves of moderate size, relatively very broad, especially near the tips, and possessing very fine veins. When the plants were grown the next year, 1906, it was observed that the seedlings of this selection were very slow to develop. In appearance while in the plant bed they very closely resembled Connecticut Seedleaf but after transplanting they assumed a very different appearance, in marked contrast with this variety. The surface and texture of

the leaves resembled Cuban as did also the shape. The plants, though slow growing in the plant bed, especially during cool weather, were strong and hardy and produced a good stand when transplanted. For the first few weeks they grew slowly but afterward made very rapid growth, producing a plot of tobacco that attracted marked attention from nearly all who saw it. The plants were apparently quite uniform; during the earlier part of the season the leaves were semi-erect and later horizontal or semi-drooping, at all times a rich, very dark green color which added to the luxurious appearance presented by the vigorous growth. The yield was good, surpassing that of Connecticut Seedleaf, its more productive parent, by 281 pounds per acre and that of Zimmer Spanish by 262 pounds.

Fig. 18. Seed plant of Hybrid 201. This is a new hybrid which seems to promise a good yield of fine appearing tobacco.

At this time (1906) this strain of Hybrid 75 was the most productive strain of tobacco yet developed by the breeding work at Germantown. A large number of seed plants were selected and measurements and notes carefully recorded. At the smoking test held that year, for the first time, at Washington,

D. C., these plants made a very good showing. Fourteen of the best ones were grown individually in duplicate rows in 1907 and the results obtained were quite surprising. We have already remarked upon the apparent uniformity of all the plants grown from the seed of 75-154. What then was our surprise when a large amount of variation was discovered among the second generation of its descendants. We can readily see how certain minor differences in the seed plants may have escaped detection but certainly nothing so striking as some of the differences noted in the growth of certain selections in 1907, could have escaped notice and further proof that these striking variations did not exist among the seed plants employed is furnished by the fact that when plots of tobacco were again grown from the original seed of 75-154 the plants again all looked alike. Nevertheless, two of the seed plants selected in 1906 produced plants light yellowish green in color and having taller stalks and longer internodes and were of much prompter growth in the plant bed than the parent form. They also possessed leaves that were long and very sharp pointed. All of these characters were in very marked contrast to the corresponding ones of the offspring of the remaining seed plants of the same origin. These characters bred true to type for several generations and seemed to be entirely fixed. The growing of these types was finally discontinued as they seemed inferior to some other strains of Hybrid 75.

The progeny of all the other seed plants resembled each other more or less but were easily distinguished from each other by differences in one or more characters. The offspring of each plant, however, was quite uniform and nearly all proved to be good yielders and for the most part the tobacco was of good quality. The most remarkable thing connected with the selections descending from 75-154 is their apparently peculiar mode of variation. Each year the progeny from single mother plants seem quite uniform, yet there has been a radical breaking up in type so that in five years breeding since the direct offspring of this plant was grown in 1906, a large number of types have been developed exhibiting a very wide range of variation in yield, quality, habit of growth and other important characters. All of these selections with the exceptions already noted, have retained the dark green color and tardiness of growth in the plant bed which was so characteristic of their common ancestor, 75-154. However, there has been considerable variation in intensity of leaf color and some of them have made such an improvement in plant bed behavior that the plants are ready to transplant but a few days later than those of ordinary varieties; other selections have varied so far in the opposite direction that it is impossible to secure plants by any ordinary means in time to produce a satisfactory crop. When the plants are once well started in the field they make rapid growth and nearly all, especially those which are slowest in the plant bed, are very resistant to extremely hot, dry weather. From this it must not be assumed that drouth resistance is necessarily correlated with slow growth during the early life of the plant, for one of the most drouth resistant strains of another hybrid is extremely prompt in germination and the growth of the seedlings more rapid than those of any other known variety.

Climatic adaptations. Not only is the drouth resistance already mentioned a marked characteristic of the selections of this hybrid which are still being grown but it actually produces a larger absolute yield in dry seasons than it does in years of normal rainfall or wet seasons. This will be brought out by a study of the results for the years 1908, 1909 and 1910 given in Table IX; 1909 was a very wet season and the other two years very dry. See also diagram

under Breeding for Special Adaptation on a later page, which shows diagrammatically the influence of wet and dry seasons upon several selections of Hybrid 75 in contrast with the effect of the same conditions upon two selections of Pennsylvania Seedleaf, a variety with opposite moisture requirements.

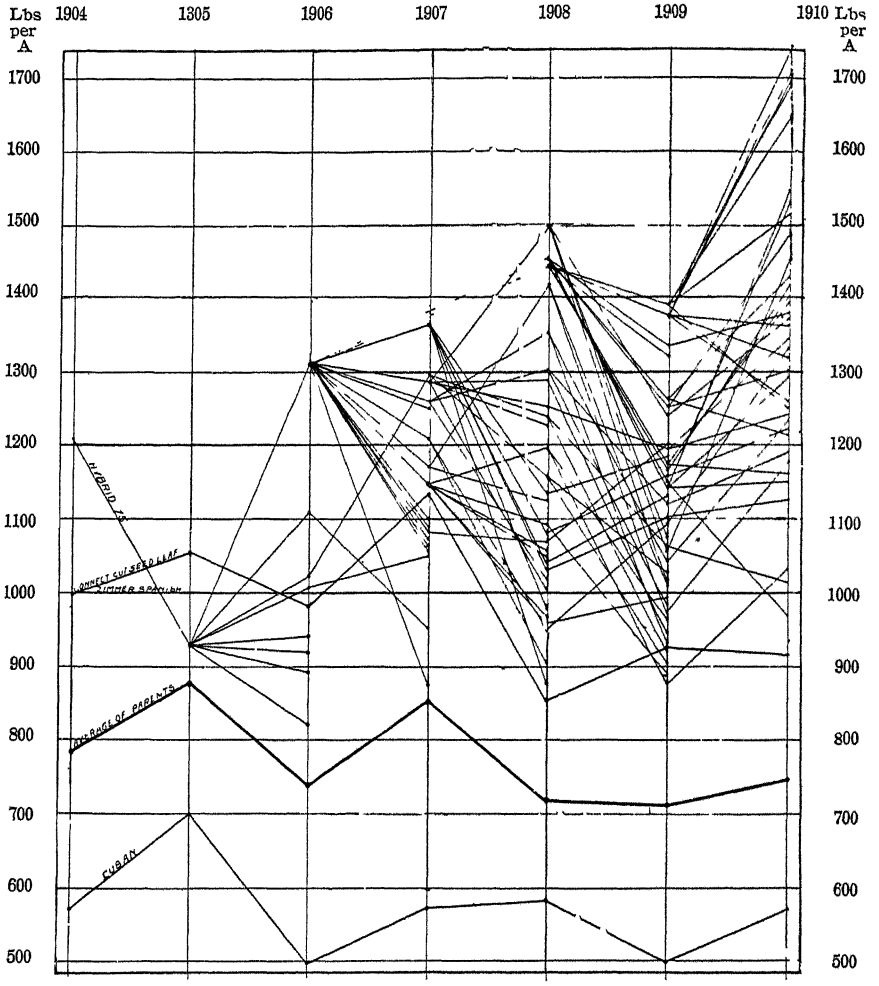


Fig. 19. Diagram showing yields and lines of descent of the various selections of Hybrid 75 in comparison with the yields of the parent varieties, Cuban and Connecticut Seedleaf.

This diagram is constructed by assuming a uniform yield of 1000 pounds per acre for Zimmer Spanish and calculating the other yields by adding to or subtracting from this quantity the proper number of pounds in each case as determined by the increases or decreases of the different strains when compared with the Zimmer Spanish checks between which they grew.

Recent yields. During the three years ending with 1910 the average yield of the best selection at the Station has been 1537 pounds per acre or about 54 percent more than the yield of Zimmer Spanish. When comparison is

made with the yields of the parent varieties we find a gain of 814 pounds per acre over the parental average or 91 pounds more than the combined yields of both parent varieties. For detailed breeding records see diagram of the several plants grown from year to year, Fig. 19.

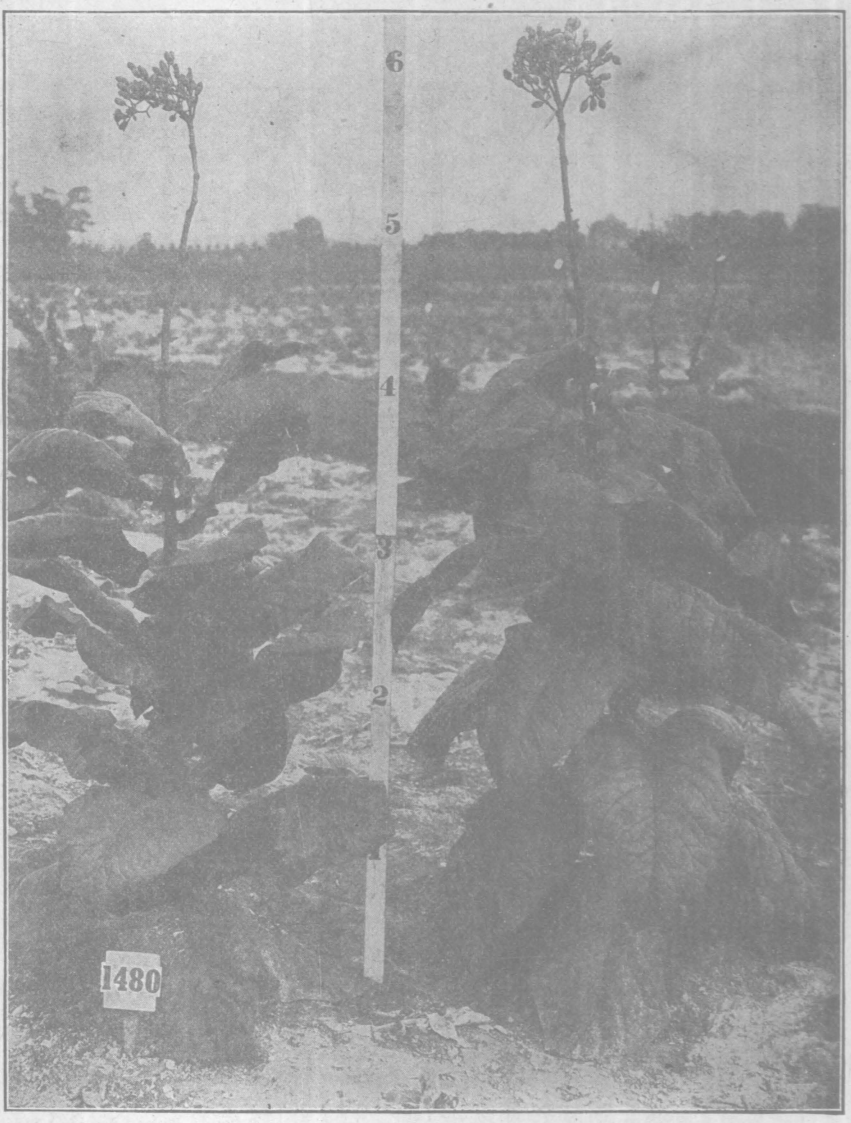


Fig. 20. Seed plants of Hybrid 89 and Hybrid 204. These are both very productive types.

Among cooperative growers who have tested selections of Hybrid 75, the yields have run from about 20 to 91 percent higher than those of Zimmer Spanish. The highest percentage gain, 91 percent, was obtained in 1909 by

Mr. Aaron Sharritt, living about five miles northeast of Germantown. The largest absolute yield was obtained by the Baughman Brothers, of Ansonia, Darke county, O. Their yield was about 1,900 pounds per acre and was just about equal to the yield of their Seedleaf tobacco. In 1911 Mr. Lewis Rice, of West Milton, O., reports the yield of the wrapper and filler grades of Hybrid 75 as being 1,748 pounds per acre as compared with a corresponding yield of Zimmer Spanish amounting to 1,288 pounds.

In most cases the quality of the tobacco has been good and the chief criticism of the growers is that it does not fall readily into any of the established classes of tobacco. Some have sold it along with Spanish and some with Seedleaf, according to the selection planted and the conditions attending its growth. The tobacco does not damage readily and has good flavor and aroma. It runs rather high in nicotine and is liked best by those who prefer a rather strong cigar.

The chief use of this hybrid will probably be for foundation stock for the making of other hybrids which will take their places in the long established classes of tobacco grown in the Miami Valley. Several such hybrids are now under investigation, among which may be mentioned number 127.

TABLE IX. Statisticts of Hybrid 75, grown at Germantown Test Farm, 1904-1910. Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 75			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 75			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1904	1,123	....	....	520	910	715	913	408	....	210	....
1905	776	....	....	596	900	748	846	28	....	—70	....
1906	1,181	1,026	1,468	598	1,187	893	1,206	288	575	—25	262
1907	1,214	927	1,408	595	1,200	898	1,044	316	510	170	364
1908	1,089	828	1,446	553	806	680	950	409	766	139	496
1909	1,026	810	1,315	462	856	659	930	367	656	96	385
1910	1,460	1,079	1,851	633	1,027	830	1,111	630	1,021	349	740
3-yr. av. 1908-1910	1,192	906	1,537	549	896	723	997	469	814	195	540

Possibilities as a wrapper type. Mr. J. E. Blohm grew in 1911 several hybrids upon rather light textured second bottom soil in Germantown and primed the leaves as they matured. Among these was a certain selection of Hybrid 75 that produced a very fine grade of wrapper tobacco which seems to compare very favorably with the best wrapper produced in Connecticut. These plantings were made late in June or the first of July and consequently made most of their growth late in the season when there was abundant rainfall. What the result would have been had the season been dry cannot be known until actual trials during such seasons are made. This strain of 75 will be tried out for wrapper purposes in a small way in 1912 by several growers. One thing in favor of using this hybrid for this purpose is the almost certainty of getting a good crop of filler if the weather or other causes should prevent it from developing into a good grade of wrapper.

SPANISH TYPE HYBRIDS

This group includes all those hybrids whose cured tobacco more or less closely resembles Zimmer Spanish. Most of them also bear more or less resemblance to this variety while growing, although such types as tall 81 and 89 are very different in their habit of growth. All the members of this group with the exception of Hybrid 127 have Zimmer Spanish blood in them, most of them being half bloods. Most of them also have Cuban and Connecticut Seedleaf among their ancestral varieties. The first hybrids of this group were produced in 1904 by cross fertilizing Zimmer Spanish plants with pollen of Cuban-Connecticut Seedleaf hybrids.

HYBRID 81

Hybrid 81 was made in 1904 by crossing Zimmer Spanish and Hybrid 54 which has already been described. Therefore, it is half blood Zimmer, one-fourth blood Cuban and one-fourth blood Connecticut Seedleaf. The first generation was rather slender and gave little promise of the excellence that has been obtained in later generations. In the second generation, two lots of seed were used in propagating this hybrid, one from an individual plant and the other from a group of plants. The offspring of the single plant yielded 1,384 pounds per acre while the progeny of the lump lot of seed produced but 949 pounds. This large difference in hereditary yielding power of different seed plants of the first generation of this hybrid is accounted for by the fact that one of the parent varieties was itself a first generation hybrid and therefore would not transmit the same combination of characters to all of its offspring; accordingly, there would naturally be some variation in the first generation of the new hybrid as was actually the case with Hybrid 81.

The accompanying diagram shows the yields and lines of descent of the various selections of this hybrid from the first to the sixth generations, inclusive. In the third generation the two better yielding selections presented a marked contrast in many important characters, being totally unlike in habit of growth and general appearance. One type, designated on the diagram by the solid lines, is low growing with numerous, very erect, smooth leaves and very short internodes. The other type, represented by broken lines, is characterized by a very tall stalk with semi-erect, rather distantly spaced leaves which show a tendency to fullness between the veins which contrasts with the smooth surface of the leaves of the low type. Another distinguishing characteristic of the tall type is a peculiar modification of the inflorescence in which the central bud never opens until after several of the latteral ones have bloomed. The descendants of both these selections though varying widely in yield and quality, remained constant in these distinguishing characters until 1910 when two plants, one from each type were found to have departed from the parent type. The one from the tall parent stock was abnormal in having the erect, smooth leaves of the low type and a stalk intermediate in height. The variant plant from the low type was characterized by a taller stalk and earlier maturity. Both plants were saved for seed and propagated in 1911 and both bred true to type, thereby proving that they were true mutants and not chance hybrids.

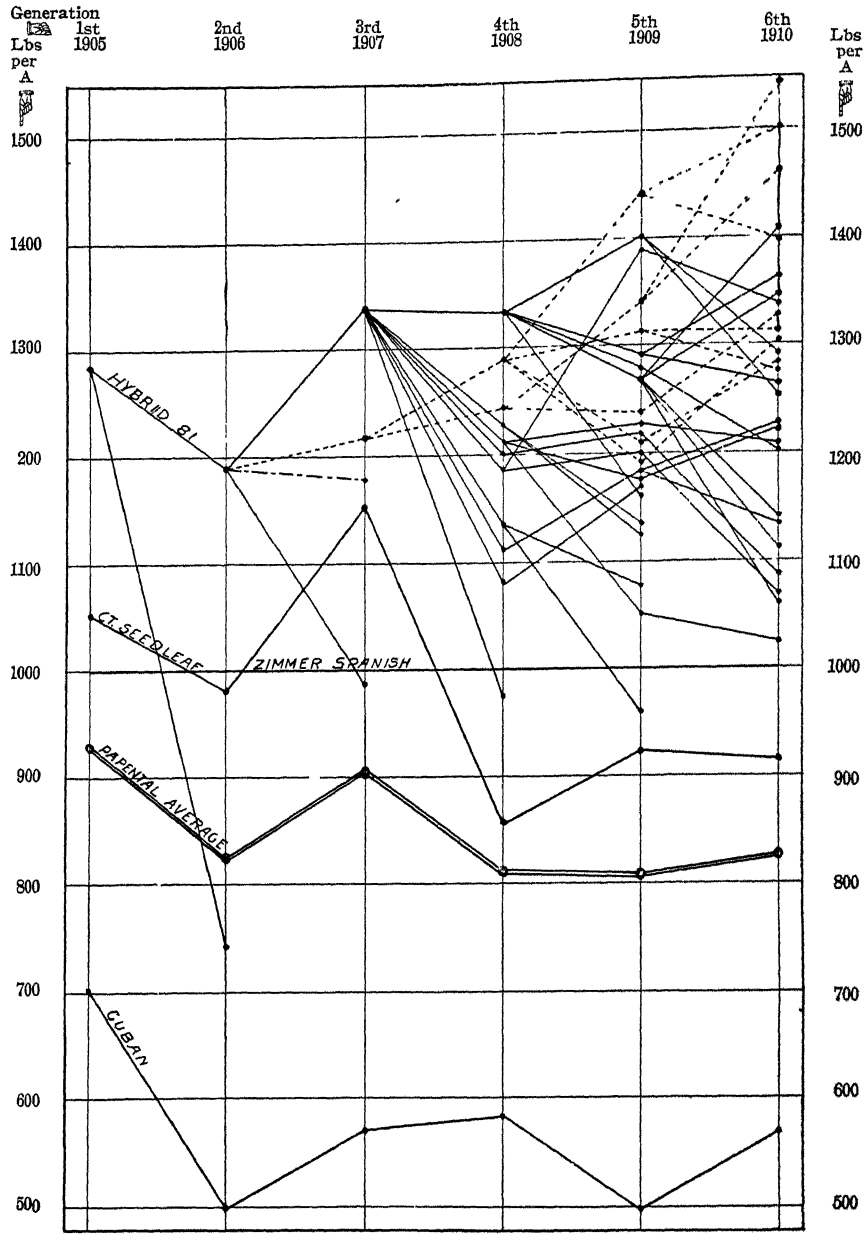


Fig. 21. Diagram showing yields and lines of descent of the several selections of Hybrid 81, also yields of the three parent varieties, Zimmer Spanish, Cuban and Connecticut Seedleaf. The solid lines represent the low type and the broken lines the tall type of the hybrid. Note the rapid increase in yield of the latter type during the last few years and the large increase over the parental average made by both types.

Both types are comparatively free from suckers and remarkably resistant to windstorms, very rarely going down even under the most trying circumstances. The better selections of both types have a fine flavor and aroma: Cigars made from them are pronounced superior to those made from Zimmer Spanish, by most persons who have tested them. Both types go through the process of fermentation very well and no damage has yet been found where the tobacco was packed in good condition.

A study of the table shows a steady increase in yields culminating in 1910 with an increase over Zimmer Spanish amounting to 258 pounds per acre for an average of all the selections of the hybrid planted. This is a gain of about 23 percent. When the best selection is taken the increase per acre is 540 pounds or about 49 percent. By referring to the table it will be seen that during the last few years this increase has been largely confined to the tall type, the low form remaining practically stationary as regards yield. The rather wide divergence in yield during the last two years found between selections tracing back to a common mother plant of the preceding season, is no doubt to be accounted for in large part by differences in environment to which the various selections were subjected, for there is a marked difference in the relative adaptability of this hybrid and Zimmer Spanish to the different types of soil and different cultural methods employed at the Test Farm. The irregularities of yield in the low type were more pronounced in 1910 as would naturally follow from the fact that these selections were that year not planted in duplicate. Another contributing cause was the scattering of the different selections over the testing grounds upon several types of soil, partly on rotation ground and partly on the plots continuously in tobacco. Ordinarily in duplicate plantings, when one planting occurs in an unusually poor place, this is compensated for so far as possible by locating the other planting in an exceptionally favorable situation. Of course there are always disturbing factors which cannot be completely controlled, but we find more consistent results where the different selections are grown side by side under nearly uniform conditions. It will be noted that the variation in yields of individual plants is not great in the case of the tall type in 1910 which was planted in duplicate with the precautions above noted.

The tall type still seems capable of improvement in the matter of yields, at least, those of 1910 upon the average are considerably better than those of the previous year. This may possibly be due to the greater drouth resistance of the tall type since 1910 was a very dry year. But if this be the true explanation, there must certainly have been an improvement since 1908, which was a still drier year, in fact, the driest summer on record in the Miami Valley. Since 1909 was an extremely wet year it seems probable that the low type of this hybrid has about the same relative adaptability to wet and dry seasons as Zimmer Spanish, by which its yields each year have been measured. Note also the yields of the other parents, Cuban and Connecticut Seedleaf, and the average yield of the three parent varieties and it will be seen that most selections of this hybrid have consistently maintained themselves much above the parental average, the best selection in 1910 yielding almost twice as much.

Tests by farmers. The low type of Hybrid 81 is now being grown by quite a number of farmers in this vicinity and at other points in the Miami Valley. The yields in 1910 ranged from about 900 to 1500 pounds per acre of the wrapper and filler grades, in all cases being higher than those of Zimmer Spanish grown under similar conditions, the gains amounting to from 17 to 46 percent of the Spanish yield. The results for 1911 are not yet all in but so far as received are

very satisfactory with yields running from about 1,475 pounds to almost a ton per acre, the gains over Zimmer Spanish ranging from 275 to about 800 pounds per acre or from 22 to about 66 percent. The greatest gains were made where the Zimmer Spanish made the largest yields; this holds good even for the percentage gains, indicating that Hybrid 81 is especially adapted to good soil and responds more largely to proper care and fertilization than does Zimmer Spanish. We would not recommend the culture of this hybrid to those growers who habitually succeed in growing but 500 or 600 ponnds of Zimmer, for under such conditions as this the yield would probably not exceed that of the latter variety and in some seasons would probably not mature.

The tall type of this hybrid has also been tested by a few growers and has given good satisfaction. Not many Spanish growers are provided with curing sheds with tiers high enough to accommodate this strain, otherwise the tall type would probably be fully as popular as the low form of the hybrid. The tall strain is slightly later than the other type but ripens more promptly after topping and cures up more rapidly in the shed. The leaves of the tall type are usually very uniform in length and furnish a larger proportion of the wrapper grade than almost any other variety. The quality is usually very good and uniform and the tobacco weighs surprisingly well.

Commercial outlook. The appearance of the tobacco after stripping is very similar to Zimmer Spanish and as before stated gives no trouble in the warehouse and makes cigars of superior quality. Notwithstanding the good qualities of Hybrid 81, there has been manifest more or less disposition on the part of tobacco buyers when they know a farmer is growing this sort to discriminate against his crop, no doubt often through prejudice, but in some cases evidently in the hope of obtaining good tobacco at reduced prices. These same dealers have repeatedly demonstrated their inability to distinguish this tobacco from Zimmer Spanish, and they buy other varieties, such as Closeleaf Spanish, which are no more similar to the true Zimmer Spanish than is Hybrid 81, and which give much more trouble in the warehouse and are superior in no way whatever; indeed there is good evidence that large quantities of tobacco of several varieties including much of that grown in Wisconsin, come to be known as Zimmer Spanish by the time they reach the cigar manufacturer. In view of all of this, we believe the time has come for the farmer to grow more productive varieties than Zimmer Spanish or demand a higher price for the latter variety.

TABLE X. Statistics of Hybrid 81, grown at Germantown Test Farm, 1905-1910. Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 81			Yield of parent varieties				Yield of Zim. Span	Increased yield of Hybrid 81			
									Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Zim. Span	Av.		Av. of all selections	Best selectio	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1905	1032	..	..	569	900	846	772	846	260	....	186	....
1906	1127	949	1384	598	1187	1206	997	1206	130	387	—79	178
1907	1227	1067	1363	595	1200	1044	946	1044	281	417	183	319
1908	1132	912	1266	553	806	950	770	950	362	496	182	316
1909	1139	874	1362	462	856	930	749	930	390	613	209	432
1910	1369	1019	1651	633	1027	1111	924	1111	445	727	258	540
3-yr. av. 1908-1910	1213	935	1426	549	896	997	814	997	399	612	216	429

For more details of the results of trials of this hybrid by growers see the chapter on "Cooperative Tests by Farmers." It should perhaps be stated here that Hybrid 81 is somewhat later than Zimmer Spanish, reaching the stage when it should be topped, about ten days later than that variety. It should stand about the same length of time after topping as other Spanish varieties. Table X gives a summary of the yields of Hybrid 81 obtained at the Germantown Test Farm from 1905 to 1910.

HYBRID 86

This hybrid is of the same parentage as Hybrid 81 and during the first few generations made an even better record so far as yields are concerned and had good smoking quality. In appearance Hybrid 86 differs from 81 in being of slightly less erect habit of growth and in possessing leaves with slightly dentate edges. During the last two years this sort has made but small gains over Zimmer Spanish and its culture will probably be discontinued. For yields see Table XI.

TABLE XI. Statistics of Hybrid 86, grown at Germantown Test Farm, 1905-1910. Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 86			Yield of parent varieties				Yield of Zim. Span.	Increased yield of Hybrid 86			
									Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Zim. Span.	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1905	1106	.		596	900	846	772	846	325	...	260	...
1906	1397	1197	1596	598	1187	1206	997	1206	400	599	191	390
1907	1224	849	1599	595	1200	1044	946	1044	278	653	180	555
1908	1151	991	1311	553	806	950	770	950	381	541	201	361
1909	956	956	956	462	856	930	749	930	207	207	26	26
1910	1211	1129	1292	633	1027	1111	924	1111	287	368	100	181
3-yr. av. 1908-1910	1106	1025	1186	549	896	997	814	997	292	372	109	189

HYBRID 89

Hybrid 89 is also a half blood Zimmer, its other parent being Hybrid 64, one of the original Cuban-Connecticut Seedleaf crosses. The first generation of 89 grown in 1905 was characterized by a slender stalk with rather long internodes and yielded only about 90 pounds more per acre than Zimmer Spanish. The following year the plants from a mixed lot of seed produced a still lower yield, falling almost to the level of Zimmer. In this second generation there was one plant apparently very superior to the rest and this alone was used to propagate the hybrid. Its progeny was fairly uniform and produced a yield of 305 pounds more per acre than Zimmer Spanish or an excess of 403 pounds over the average yield of its three parent varieties. The plants in this generation still showed some variation but to a much less degree than in the preceding year. Beginning with this year (1907) Hybrid 89 has shown a steady and rapid increase in yield from the selections planted. See Fig. 22.

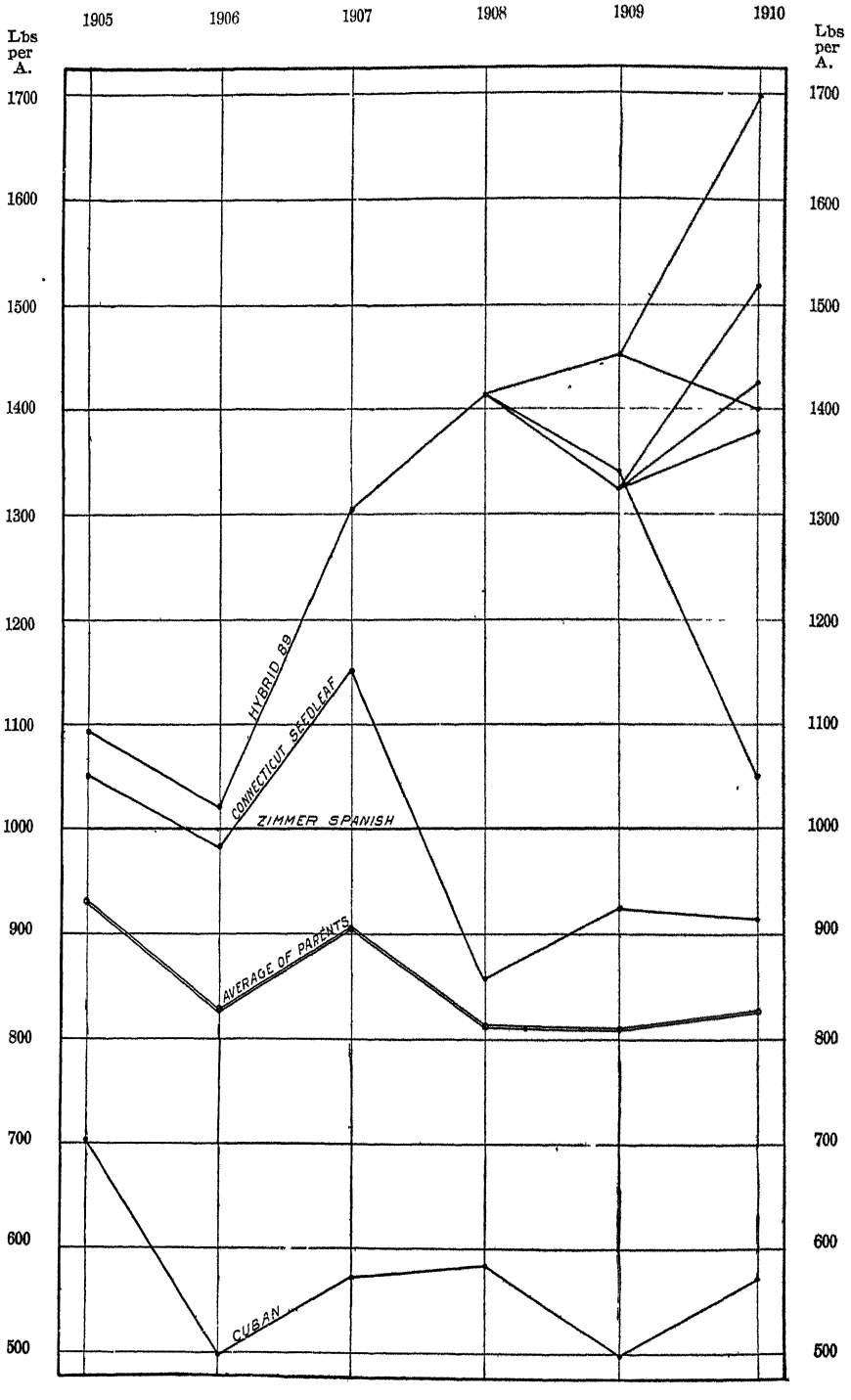


Fig. 22. Diagram showing the yields of and lines of descent of the several selections of Hybrid 89 together with the yields of its parents.

Again in 1907 but a single seed plant was chosen to represent this hybrid in the breeding plots for 1908. This resulted in yields showing gains of 412 and 592 pounds per acre, respectively, over Zimmer Spanish and the average of the parent varieties. This generation showed very little variation in external characters and three plants were chosen for continuing the breeding out of this hybrid.

The yields in 1909 ran from 321 to 447 pounds per acre more than those of Zimmer Spanish and the best selection exceeded the parental average by 628 pounds. While all three selections made good yields one of them showed certain signs of degeneracy, among which was a predisposition to the Mosaic disease, a tendency which was much more marked in the offspring of the only seed plant of this selection planted in 1910. This resulted in a decided lowering of the yield as will be readily seen upon consulting the diagram.

In 1910 six selections were grown and all but the one already alluded to did remarkably well, being very vigorous and yielding from 381 to 689 pounds more than Zimmer. The average gain over Zimmer was 434 pounds per acre, while the gains over the parental average amounted to 621 and 876 pounds per acre, respectively, for the average of all selections planted and for the best selection.

The selections of Hybrid 89 which are still being grown are characterized by an intense green color of the leaves, by a tall stalk, the upper part of which is slender and tapers to a sharp point, giving the plants before topping the appearance of elongated cones. These tops are also very limber and in windy weather become crooked when the plants are bagged for seed saving purposes. The bending, however, rarely extends down to the portion of the stalk bearing the leaves.

TABLE XII. Statistics of Hybrid 89, grown at Germantown Test Farm, 1905-1910. Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per arce

Yield	Yield of Hybrid 89			Yield of parent varieties				Yield of Zim. Span.	Increased yield of Hybrid 89			
									Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seed-leaf	Zim. Span.	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1905	936	..	....	596	900	846	781	846	165	...	90	. .
1906	1226	....	..	598	1187	1206	997	1206	229	...	20	.
1907	1349	.	.	595	1200	1044	946	1044	403	...	305	...
1908	1362	1362	1362	553	806	950	770	950	592	592	412	412
1909	1298	1251	1377	462	856	930	749	930	548	628	368	447
1910	1545	1163	1800	633	1027	1111	924	1111	621	876	434	689
3-yr. av. 1908-1910	1402	1259	1513	549	896	997	814	997	587	699	405	516

One of the striking peculiarities of Hybrid 89 is the fact that it commonly yields about 50 percent more than its appearance in the field would indicate. This is the more remarkable because of the fact that the leaves when stripped from the stalks are found to be even shorter than they appeared while the plants were growing in the field. The large yields, therefore, must be due to the unusual thickness of the leaves. This tendency to uncommonly thick leaves is a drawback on soils that tend to produce heavy bodied tobacco but should be an advantage under soil conditions that tend to produce flimsy tobacco. This

tobacco has shown remarkable capacity to make rapid gains in weight during the latter part of the ripening period when kept free from suckers, in one instance gaining 343 pounds per acre or 22 percent in four days.

In the tests by cooperative growers this hybrid has produced about 50 percent more than Zimmer Spanish. For details of the Station yields see Table XII and Fig. 22.

HYBRIDS 104 AND 108

These two hybrids are of similar origin to those just discussed and in the first generation were the most promising ones that up to that time had been produced. In habit of growth, general appearance and vigor they were almost ideal from the Zimmer Spanish standpoint. Our efforts to develop valuable new varieties from these hybrids resulted in failure and we simply mention them in passing to show some of the difficulties and sources of disappointment in the breeding work. These two hybrids are in marked contrast to 81 and 89, whose appearance in the first generation was much inferior but from which such excellent results in the way of valuable new varieties have been obtained.

HYBRID 106

Here again we have a hybrid one-half Zimmer Spanish, one-fourth Cuban and one-fourth Connecticut Seedleaf. The first generation was quite variable and one plant was a freak, having 24 good sized leaves crowded upon a stalk only 21 inches long. The leaves were smooth like those of Zimmer Spanish but much stiffer and stood from the stalk at an angle of about 80 degrees. A remarkable fact connected with this plant is that it cured up perfectly while the remaining plants upon the same lath, though possessing normally spaced leaves, were all badly damaged by shed burn. This freak and two other plants were propagated the following year (1906), the freak plant alone making a satisfactory yield. See Table XIII.

TABLE XIII. Statistics of Hybrid 106, grown at Germantown Test Farm, 1905-1910
Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 106			Yield of parent varieties				Yield of Zim. Span.	Increased yield of Hybrid 106			
									Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Zim. Span.	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1905	1028	...	....	596	900	846	781	846	247	..	182	...
1906	1164	985	1388	598	1187	1206	997	1206	167	391	−42	182
1907	1052	918	1226	595	1200	1044	946	1044	106	280	8	182
1908	1058	915	1217	553	806	950	770	950	288	447	108	267
1909	1069	972	1153	462	856	930	749	930	320	404	139	223
1910	1311	1191	1431	633	1027	1111	924	1111	387	807	200	320
3-yr. av. 1908-1910	1146	1026	1267	548	896	997	814	997	335	418	149	270

The offspring of the freak were apparently quite uniform but not a single plant exhibited the much shortened internodes of the parent plant, and no such types have appeared up to the present time among any of its descendants grown from self fertilized seed. In an interhybrid between this freak plant and

Hybrid 79, however, a variation was found having this same abnormal character in somewhat modified form. This offshoot type has bred true for several generations. For further description see Hybrid 126.

Considerable difference in appearance has developed among the various selections of Hybrid 106 since the second generation and likewise in productivity as can be seen by referring to the table of yields. Several cooperative growers have obtained good results with this hybrid and in one case an experienced tobacco buyer stated that the crop had the appearance that Zimmer Spanish used to have before it was "run out," and altogether, praised it very highly. Perhaps it should be stated that this buyer thought he was examining a crop of pure Zimmer Spanish.

In addition to its value as a commercial sort, Hybrid 106 is one of the parents of two of the most promising of the newer hybrids, numbers 224 and 238, the former being especially good.

HYBRID 126

This is the hybrid already referred to under Hybrid 106 as having inherited in one of its variations the peculiarly shortened internodes of its paternal ancestor, the freak plant of Hybrid 106 already described. Both parents of Hybrid 126 had the same parent varieties, so that the ancestry is the same as for the Spanish type hybrids already described. It is not a particularly promising looking variety in the field as the leaves have a rather dead and papery appearance and the plants look small and incapable of making a good yield. As a matter of fact, the cured tobacco is of fine quality and the yields have been somewhat above those of Zimmer Spanish. Its permanent usefulness, if any, will probably be as foundation stock for making new hybrids with other varieties having longer internodes. Table XIV gives the record of yields.

TABLE XIV. Statistics of Hybrid 126, grown at Germantown Test Farm, 1906-1910
Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 126			Yield of parent varieties				Yield of Zim. Span.	Increased yield of Hybrid 126			
									Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Zim. Span.	Cuban	Ct. Seed-leaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1906	1378	.. .	....	1206	598	1187	997	1206	381	...	172	...
1907	1183		....	1044	595	1200	946	1044	237	...	139	...
1908	1169	1169	1169	950	553	806	770	950	399	399	219	219
1909	1134	1134	1134	930	462	856	749	930	385	385	204	204
1910	1218	1166	1269	1111	633	1027	924	1111	294	345	107	158
3-yr. av. 1908-1910	1174	1156	1191	997	549	896	814	997	360	377	177	194

HYBRID 127

Hybrid 127 resembles Zimmer Spanish in many respects but contains no blood of this variety or of any other sort even remotely resembling Zimmer. It was produced in 1905 by crossing Hybrid 80 by Hybrid 75 and as can be seen by tracing out its pedigree in the list of hybrids found on page 410, its three parent varieties are represented in its make-up in the following proportions:

Cuban ⅜, Connecticut Seedleaf ⅜ and Ohio Seedleaf ¼. The type selected for propagation from the numerous second generation variations is a low growing form somewhat resembling the low type of Hybrid 81 already described.

Like other hybrids with unfixed types for their parents Hybrid 127 showed a great deal of variation in the first generation, thus permitting of selective improvement to such an extent that better yields were obtained in the second generation than in the first, a condition which does not occur when both parents are fixed varieties. The yields of this hybrid have been good but the quality somewhat variable. One selection is remarkably drought resistant and makes large yields in any kind of weather, not being depressed in yield by wet weather, as is the drought resistant types of Hybrid 75, from which it also differs in being an exceedingly rapid grower in the plant bed. The yields are summarized in Table XV.

TABLE XV. Statistics of Hybrid 127, grown at Germantown Test Farm, 1906-1910. Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 127			Yield of parent varieties				Yield of Zim. Span.	Increased yield of Hybrid 127			
									Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Ohio Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1906	1331	....	....	598	1187	1607	1131	1206	200	...	125	...
1907	1478	....	....	595	1200	1532	1109	1044	369	...	434	...
1908	1156	1049	1344	553	806	1372	910	950	246	434	206	394
1909	1220	1110	1298	462	856	1445	921	930	299	377	290	368
1910	1427	1312	1585	633	1027	1623	1094	1111	333	491	316	474
5-yr. av. 1908-1910	1268	1157	1409	549	896	1480	975	997	293	434	271	412

HYBRID 129

Hybrid 129 contains an equal amount of the blood of each of its four parent varieties, viz., Zimmer Spanish, Cuban, Connecticut Seedleaf and Ohio Seedleaf. The strain which we are growing of this hybrid was selected because of its remarkably fine appearance at stripping time, in which respect it has no superior. The cured tobacco closely resembles Zimmer Spanish but has the latter's fine qualities in still greater degree. Smoking tests have also revealed fine flavor and aroma. The general appearance while growing in the field is intermediate between Zimmer Spanish and Little Dutch. It has never been a heavy yielder, averaging only about 100 pounds per acre more than Zimmer Spanish. It has been carried only because of its superb quality. Perhaps it may prove useful as one of the parents of hybrids yet to be made. For yields see Table XVI.

TABLE XVI. Statistics of Hybrid 129, grown at Germantown Test Farm, 1906-1910. Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 129			Average yield of parent variety	Yield of Zimmer Spanish	Increased yield of Hybrid 129			
						Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection			Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1906	1386	....	...	1150	1206	236	...	180	...
1907	1288	1288	1288	1093	1044	195	195	244	244
1908	1084	1084	1084	920	950	164	164	134	134
1909	950	880	1019	923	930	27	96	20	89
1910	1214	1004	1403	1099	1111	115	304	103	292
3-yr. av. 1908-1910	1083	989	1169	981	997	102	188	86	172

HYBRID 157

Hybrid 157 is a half blood Zimmer Spanish, one-fourth Ohio Seedleaf and one-eighth each Cuban and Connecticut Seedleaf. Its immediate parents were Zimmer Spanish and Hybrid 78. In the first generation it made a very remarkable yield and was desirable from the standpoint of other field characters. Three selections were grown in the second generation; since that time it has been propagated each year by using a single seed plant. This hybrid as can be seen from the diagram, Fig. 23, page 441, in the record of its yields presents a very peculiar and interesting history. In the second generation there was a very decided drop in yield followed by a still further decrease in the third. In the fourth generation there was a slight gain followed by a very remarkable one in the fifth, bringing the yield up to about the level of the first generation.

TABLE XVII. Statisticts of Hybrid 157, grown at Germantown Test Farm, 1906-1910. Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 157			Average yield of parent variety	Yield of Zimmer Spanish	Increased yield of Hybrid 157			
						Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection			Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1906	1701	....	....	1150	1206	551	....	495	....
1907	1171	1039	1243	1093	1044	78	150	127	199
1908	1036	1036	1036	920	950	116	116	86	86
1909	1041	1041	1041	923	930	118	118	111	111
1910	1610	1610	1610	1099	1111	511	511	499	499
3-yr. av. 1908-1910	1229	1229	1229	981	997	248	248	232	232

In appearance Hybrid 157 very closely resembles Zimmer Spanish, the leaves being almost exactly like those of the latter variety except for their larger size and slightly more drooping habit. This is one of the few hybrids

that in comparison with Zimmer Spanish is relatively better adapted to continuous culture than to rotative cropping. This does not mean that better yields cannot be obtained when a proper rotation is followed but it does mean that the gains over Zimmer Spanish will be larger under continuous culture than under rotation. In this respect it is in marked contrast with Hybrid 54 and many others which made much larger gains over Zimmer when grown in rotation with other crops, as well as making larger absolute yields per acre. If upon thorough testing out Hybrid 157 proves to have good quality it should prove a valuable new variety for those growers so situated that it is necessary for them to practice continuous culture of tobacco to a large extent. Table XVII summarizes the yields of this hybrid.

HYBRID 168

Hybrid 168 was made in 1905 and was supposed to be a cross between two Zimmer Spanish plants made for the purpose of ascertaining whether there would be any increase in vigor resulting from crossing within the limits of a fixed variety. However, there has been considerable variation in the offspring of this mating, and as this is not in accordance with the behavior of numerous other crosses within the same variety, we assume that one of the parents must not have been a pure Zimmer Spanish plant. The range and character of the variation indicate that the source of error may have been due to the unintentional application of some pollen of a half blood Zimmer plant through the failure to cleanse properly the instruments used in the hybridizing work. It is definitely known that on the same day a number of hybrids were made, using such pollen on various other varieties and hybrids. If this be the case, then Hybrid 168 is really a three-quarter blood Zimmer with the other parents unknown.

TABLE XVIII. Statistics of Hybrid 168, grown at Germantown Test Farm, 1906-1910 Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 168			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 168			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Zim Span.	Zim. Span.	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1906	1391	..	..	1206	?	?	1206	....	....	185	....
1907	1229	1220	1236	1044	?	?	1044	....	....	185	192
1908	1085	1033	1113	950	?	?	950	...	....	135	163
1909	1130	1096	1163	930	?	?	930	....	....	200	233
1910	1397	1382	1412	1111	?	?	1111	....	....	286	301
3-yr. av. 1908-1910	1204	1170	1229	997	?	?	997	....	....	207	232

The plants of the selection retained are very similar to pure Zimmer Spanish but differs slightly, in being a few days later, in having slightly rounder pointed leaves, slightly shorter internodes, and in being considerably more productive. The cured tobacco is indistinguishable from that of pure Zimmer as the difference in leaf shape is not sufficient to identify it. It is only when the two sorts are compared when growing under like conditions that the difference in leaf shape can be recognized.

No seed of this sort has as yet been distributed but if the demand becomes insistant for a new variety still more closely resembling Zimmer Spanish than does Hybrid 81 and other like types, it will be introduced to the growers of the Miami Valley. By referring to Table XVIII it will be seen that the yields have been sufficiently above those of Zimmer to warrant giving it a trial.

HYBRID 224

Hybrid 224 has already been alluded to under the discussion of its pistil parent, Hybrid 106. This hybrid was made in 1906 and as the two parents bore considerable resemblance to each other there has not been the wide range of variation noted in many of the preceding ones. But a single seed plant has been used each year in propagating this hybrid. The first and second generations thus handled made approximately the same yield but in the third a large increase was obtained which amounted to a gain over Zimmer Spanish of 342 pounds per acre. This hybrid shows a very close resemblance to Zimmer Spanish, the chief difference being a slightly taller stalk bearing several more leaves and in being perhaps from 5 to 7 days later in blooming and ripening. The leaves themselves are practically indistinguishable from those of Zimmer Spanish both while on the growing plant and in the cured tobacco. Perhaps they are slightly shorter than the leaves of Zimmer Spanish grown under similar conditions. During the curing process at a certain stage there is a very remarkable difference between this hybrid and the above named variety, for its leaves before turning the reddish brown or chestnut color so characteristic of Zimmer Spanish, first turn a golden yellow which later changes to the typical Zimmer color so that by the time the curing process is complete the two sorts are again indistinguishable.

It is unusual to distribute a hybrid variety of tobacco after having grown but three generations, but as this hybrid showed so little variation or rather the range of variation was so narrow that while not absolutely a fixed type, it may be deemed so for practical purposes, and was distributed in a small way in the spring of 1911. The results were so promising that all who tried it are intending to grow it again in 1912 upon a larger acreage. Unfortunately we have not as yet succeeded in securing any exact data as to the gains over Zimmer Spanish obtained by cooperative growers in 1911.

As judged by the single season of 1911, Hybrid 224 is less troublesome to sucker than Zimmer Spanish and is not blown down so readily by the wind, although inferior in this respect to hybrids 81 and 77. The suckers show much less tendency to develop on the lower portion of the stalk than is the case with Zimmer. When no suckers were removed in certain plots of the sucker test the maximum number to develop on one plant was four, although the tobacco was allowed to stand five weeks after topping. Of course when the top suckers were removed as they should be, others developed lower down but not to such an extent as with most varieties. However, before final judgment can be pronounced on the suckering propensities of this hybrid, it will have to be observed through a period of years embracing a variety of weather conditions. As compared with Zimmer Spanish there is one disadvantage in that the suckers when allowed to get very old are exceedingly tough and difficult to remove, but since such practice is very unwise under all circumstances, this is not such a serious drawback as might at first appear.

In the field up until the time of coming into bloom it is practically impossible to distinguish this hybrid from Zimmer Spanish. About the time the latter variety begins to blossom, Hybrid 224 rapidly shoots up from 4 to 6

inches higher with the development of a correspondingly larger number of leaves, and comes into bloom about a week later than the Zimmer. In very hot, dry weather, careful observation shows less tendency to wilt than is manifest by Zimmer Spanish, but this is not marked enough to serve to distinguish the two varieties except in extreme cases.

The smoking quality of Hybrid 224 is very good and while very closely resembling Zimmer Spanish in flavor and aroma, it has been almost unanimously pronounced superior to that variety by those who have tested it. This, together with its close resemblance to the above named variety, has caused a very strong demand for seed and the acreage that will be grown this year is limited only by the amount of seed available for distribution. The resemblance of this new sort to Zimmer Spanish is so close that a sample of this hybrid at a tobacco show was picked by a well known and capable tobacco merchant as being a pure, fine type of that variety. Table XIX summarizes the yields to date.

TABLE XIX. Statisticts of Hybrid 224, grown at Germantown Test Farm, 1908-1910 Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 224			Yield of parent varieties				Yield of Zim. Span.	Increased yield of Hybrid 224			
									Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Zimmer	Cuban	Ct. Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1908	1135	....	..	950	553	806	770	950	365	....	185	....
1909	1122	...	....	930	462	856	749	930	373	....	192	....
1910	1453	..	.	1111	633	1027	924	1111	529	....	342	....
3-yr. av. 1908-1910	1237	....	.	997	549	896	814	997	423	....	240	....

HYBRID 238

Hybrid 238 is a cross between hybrids 81 and 106, both half blood Zimmer hybrids already described. This hybrid is remarkable for having made in the first generation a very large increase over its parents. though both were of similar origin and themselves considerably alike. This first generation also possessed very good quality and a very desirable habit of growth and is one of the types under consideration as of possible value in the commercial growing of first generation hybrid tobaccos. A very decided drop in yield occurred in the second generation and was followed by a good gain in one of the two selections grown in the third year, 1910.

The better yielding selection grown in 1910 had rather short leaves of very erect habit, and a tall, slender stalk with short internodes. The numerous leaves were of a very intense green color and showed absolutely no tendency to wilt even during the hottest, driest weather when the Zimmer growing alongside wilted very much and Hybrid 110, which was also growing near, wilted still more. This freedom from wilting is not mentioned because it is necessarily correllated with increased productiveness or even resistance to hot, dry weather for it is not. Hybrid 110 just mentioned is really more resistant to such conditions than 238 and made a greater yield, though showing excessive tendency to wilting.

The smoking quality of the seed plants tested was not very good on the average, but a few were fair. Whether the quality can be improved by further selection remains to be determined. A first generation hybrid between this selection and Hybrid 75 made a remarkably fine showing in 1911, being very productive and desirable in all other field characters. Its quality has not yet been determined but if satisfactory, it will be tried again in 1912. For yields see Table XX.

TABLE XX. Statistics of Hybrid 238, grown at Germantown Test Farm, 1908-1910. Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 238			Yield of parent varieties				Yield of Zim. Span.	Increased yield of Hybrid 238			
									Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Zim. Span.	Cuban	Ct. Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1908	1421	1421	1421	950	553	806	770	950	651	651	471	471
1909	961	874	1034	930	462	856	749	930	212	285	31	104
1910	1359	1226	1491	1111	633	1027	924	1111	435	567	248	380
3-yr. av. 1908-1910	1247	1174	1315	997	549	896	814	997	433	501	250	318

SEEDLEAF HYBRIDS

All the hybrids of this group not only resemble Seedleaf in general appearance and in the character of the cured tobacco, but all of them have more or less Seedleaf blood in them, most of them being crosses between two Seedleaf varieties. The principal hybrids of this group are numbers 179, 182, 190, 199, 200, 201 and 204. The remainder of this chapter is occupied by individual accounts of these.

HYBRID 179

This is a cross between Pennsylvania Seedleaf and Four Sucker which appears to be but a selection of the same variety. The first generation of this hybrid made, in 1907, the highest yield of any sort grown that year at the Station Farm. This yield amounted to 708 pounds per acre more than the yield of Zimmer Spanish and 282 pounds more than Pennsylvania Seedleaf. As to whether this large, apparent increase over the latter variety was due to the stimulus of hybridization or to error arising from its being planted in a situation to which it was relatively better adapted than was the case with its parent variety, cannot be definitely known. However, it is thought that at least part of the increase was due to cross fertilization, for in a number of cases, crosses between two very similar and closely related selections of some of the older hybrids have invariably resulted in increased yields in the first generation and it would seem probable that the same relation would hold for the first generation of crosses between different selections of other varieties.

In 1908 the second generation made a gain over Pennsylvania Seedleaf of about 200 pounds per acre and the following year fell almost as far below the

parent variety, but again shows a small gain in 1910. This may indicate that this selection of Hybrid 179 is better adapted to dry and less adapted to wet seasons than is Pennsylvania Seedleaf which as compared with Zimmer Spanish does much better in wet seasons. The yields of Hybrid 179 are recorded in table XXI.

TABLE XXI. Statistics of Hybrid 179, grown at Germantown Test Farm, 1907-1910 Yields compared to those of its Parent Varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 179			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 179			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Pa. Seedleaf	Four Sucker	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1907	1,752	....	....	1,470	1,470	1,470	1,044	282	....	708	....
1908	1,485	1,485	1,485	1,287	1,287	1,287	950	198	198	535	535
1909	1,331	1,315	1,346	1,483	1,483	1,483	930	—152	—137	401	416
1910	1,631	1,622	1,640	1,547	1,547	1,547	1,111	93	84	520	529
3-yr. av. 1908-1910	1,482	1,474	1,490	1,439	1,439	1,439	997	43	51	485	493

HYBRID 182

Hybrid 182 is a cross between Pennsylvania and Black Seedleaf and the average yields of all selections have varied but little from the average of the parent varieties, while the best selection has outyielded them by about 200 pounds per acre for the last two years. The failure to show a gain over the parental average in the first generation is readily accounted for by the fact that the tobacco was set so late that it did not have time properly to mature which was not the case with the parent varieties. The cured tobacco has been quite similar to Pennsylvania Seedleaf and came through the smoking tests with a fairly good record. For yields see table XXII.

TABLE XXII: Statistics of Hybrid 182, Grown at Germantown Test Farm, 1907-1910 Yields compared to those of its Parent Varieties and Zimmer Spanish

Pounds per acre

Year	Yield of Hybrid 182			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 182			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Pa. Seedleaf	Black Seedleaf	Av.		Av. of all Selections	Best Selection	Av. of all selections	Best Selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1907	1,522	....	....	1,470	1,581	1,526	1,044	—4	....	478	....
1908	1,294	1,099	1,484	1,287	1,438	1,363	950	—69	121	344	534
1909	1,505	1,389	1,682	1,483	1,463	1,473	930	32	209	575	752
1910	1,637	1,360	1,782	1,547	1,635	1,591	1 111	46	191	526	671
3-yr. av. 1908-1910	1,479	1 283	1 649	1,439	1 512	1,476	997	3	173	482	652

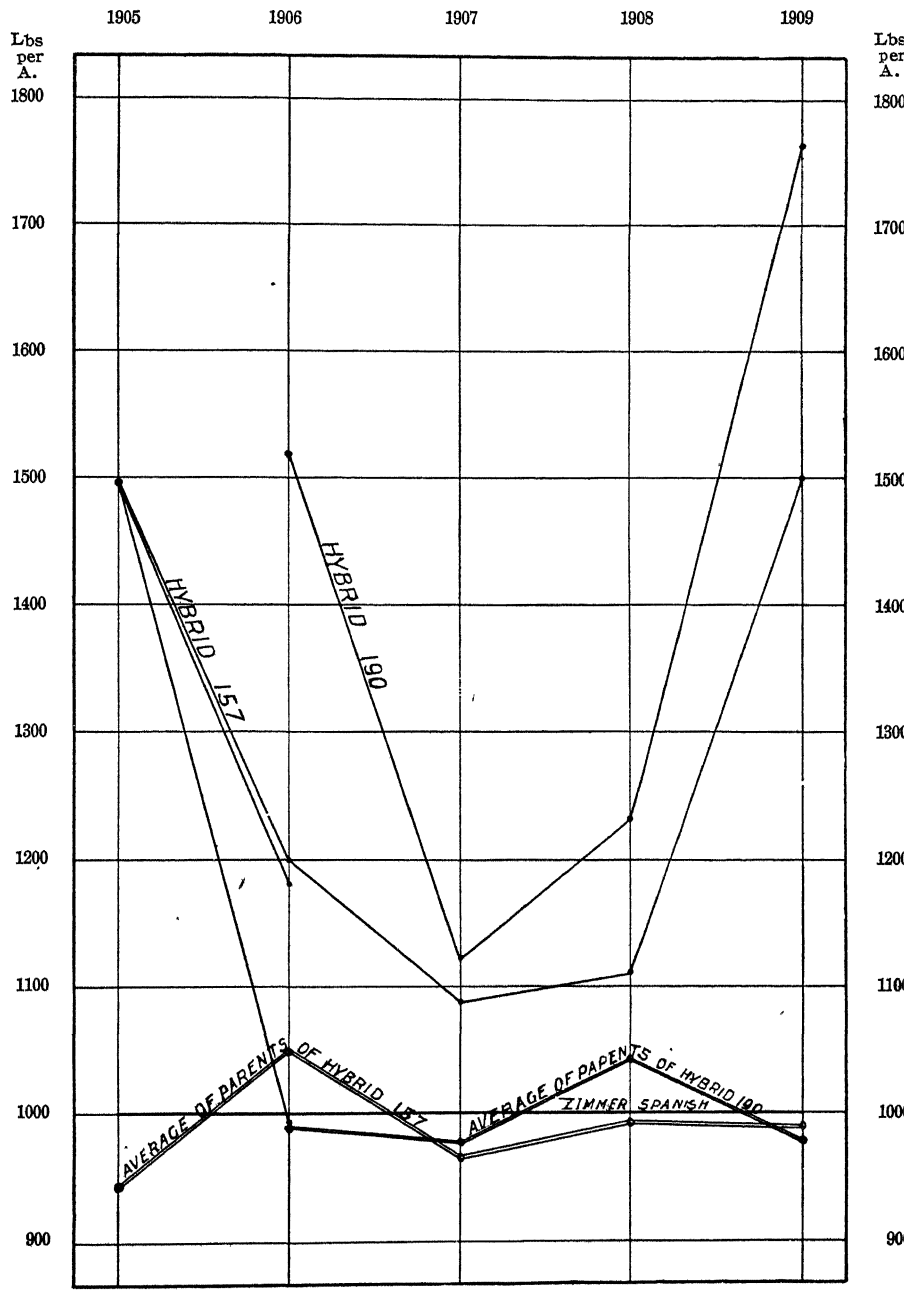


Fig. 23. Diagram showing the yields and lines of descent for Hybrids 157 and 190 and the average yields of the parents of each. Note the low yields in the second and third generations.

HYBRID 190

Hybrid 190 is a cross of Pennsylvania Seedleaf and Vuelta, a Cuban variety and a very small yielder. This hybrid in the first generation outyielded its more productive parent by nearly 100 pounds per acre notwithstanding that the other parent under similar conditions made the low yield of 595 pounds per acre. As would be expected from the very great difference in the two parent varities, the range of variation in the second generation both as to yield and other characters was very great. The yield this year being over 200 pounds below that of its larger parent and but 134 pounds above that of Zimmer Spanish. The best plant only was saved for seed and the result the next year was still farther below the Pennsylvania Seedleaf in yield, but the gain over Zimmer Spanish was greater. Much variation was still manifest but not to the extent present in the second generation. Again a single seed plant was chosen to propagate this hybrid and the result in 1910 was the large yield of 1872 pounds per acre of 325 pounds more than the more productive parent, Pennsylvania Seedleaf, this being a gain over Zimmer Spanish of 761 pounds per acre and of almost 800 pounds over the parental average.

Hybrid 190 is of even more erect habit of growth than Pennsylvania Seedleaf and a little later in maturing. On the whole it rather closely resembles this variety but has distinguishing characteristics hard to describe. The smoking quality so far as tested is good and on the whole this is one of the most promising seedleaf types. See table XXIII and Diagram Fig 23.

TABLE : Statistics of Hybrid 190, grown at Germantown Test Farm, 1907-1910 Yields compared to those of its Parent Varieties and Zimmer Spanish

Pounds per acre

Year	Yield of Hybrid 190			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 190			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Pa. Seedleaf	Vuelta	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1907	1,564	....	....	1,470	595	1,033	1,044	531	....	520	....
1908	1,084	....	....	1,287	553	920	950	164	....	134	....
1909	1,162	....	....	1,483	462	973	930	189	....	232	....
1910	1,872	....	....	1,547	633	1,090	1,111	782	....	761	....
3-yr. av. 1908-1910	1,373	....	....	1,439	549	994	997	379	....	376	. ..

HYBRID 199

Hybrid 199 was produced in 1906 and is a cross between Ohio Seedleaf and Big Graham. In the first generation it produced a yield of 471 pounds per acre more than Zimmer Spanish, a gain of about 50 pounds over the average of the two parent varieties. The second generation grown in 1908 was quite variable and yielded slightly less than the parental average. The third generation was also quite variable for most of the selections grown and on the average produced about the same as the average yield of Ohio Seedleaf and Big Graham, the parent varieties, the best selection making 53 pounds per acre more than this average.

In 1910 we find a marked improvement in yields, the average of the nine selections grown being 684 pounds more than Zimmer Spanish and 239 pounds more than the average of the parent varieties, while the best selection outyielded Zimmer Spanish and the parental average by 831 and 386 pounds respectively. This was much better than the yields of Ohio Seedleaf, Black Seedleaf or any of the standard Seedleaf varieties.

In appearance there was much difference in many important characters between the different selections, but within the selections the variation was very much reduced as compared with earlier generations. Some of the selections had broad leaves like Ohio Seedleaf, some had narrow leaves like Big Graham and others were intermediate in this respect. Some had tall stalks, some short and some medium in length, and some were of drooping habit, some semi-erect and strange to say, some were quite erect in habit of growth, though both parents are of decidedly drooping habit. One selection (see illustration, Fig. 16, page 392) produced plants of very great size with large, drooping leaves; a single plant of this strain produced one pound of cured tobacco, the largest yield of a single plant on record in the history of our breeding work with tobacco. Another selection, while having somewhat smaller leaves, grows to an immense height and has from 30 to 35 leaves per plant and in some cases even more. The tall plant shown in the illustration, Fig. 30, had 37 leaves and was nine feet tall to the top of the seed head and produced over fourteen ounces of cured tobacco.

The tall type just described, in 1911, on the farm of the junior author on land heavily fertilized and with thorough cultivation, produced a yield of wrapper and filler amounting to 3,693 pounds per acre. If to this we add the trash and a small quantity of "fat stems" the total yield is found to be over two tons per acre. Another type of this hybrid on less highly fertilized ground at the Station, and with late transplanting, yielded 3,500 pounds of wrapper and filler per acre. This is perhaps the more productive of the two selections. This selection cured up extremely fast for so heavy a tobacco and the quality appeared to be very good. Another peculiarity of this type is the extreme ease with which the large stalks can be cut with the tobacco shears.

TABLE XXIV: Statistics of Hybrid 199, grown at Germantown Test Farm, 1907-1910. Yields compared to those of the Parent Varieties and Zimmer Spanish

Pounds per acre

Year	Yield of Hybrid 199			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 199			
								Over Average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Ohio Seedleaf	Big Graham	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1907	1,515	....	....	1,532	1,399	1,466	1,044	49	....	471	....
1908	1,249	1,073	1,325	1,372	1,273	1,323	950	—74	2	299	375
1909	1,342	1,081	1,399	1,445	1,246	1,346	930	—4	53	412	469
1910	1,795	1,687	1,942	1,623	1,489	1,556	1,111	239	386	684	831
3-yr. av. 1908-1910	1,462	1,280	1,655	1,480	1,336	1,408	997	54	247	465	558

The smoking quality of several of the best yielding selections is very good and apparently is more uniform for the leaves on different parts of the plants than is common with most varieties. The selections seem better adapted to dry

weather than do their parent varieties; the greatly increased gains over the latter made in the dry year, 1910, may be entirely due to hereditary improvement by selection which has certainly been responsible for at least part of the increase.

Though not entirely fixed in type this hybrid was given to a few growers for testing in 1911 and although there was some variation among the plants, these growers were on the whole well pleased with the new variety and there has been a large demand for seed for 1912. For studying the yields of Hybrid 199 in comparison with those of Zimmer Spanish and the parent varieties reference is made to Table XXIV.

HYBRID 200

Hybrid 200, which is a cross between Ohio Seedleaf and Little Graham, made in 1906, is similar in general appearance to Hybrid 199, though more of the variations have narrow leaves. It, however, has been markedly less productive and the smoking quality of most selections is also inferior to that of the latter hybrid. In view of the superiority of Hybrid 199, with the exception of the propagation of a few promising plants of one of the selections grown in 1910, the culture of Hybrid 200 has been abandoned. For yields see Table XXV.

TABLE XXV: Statistics of Hybrid 200, grown at Germantown Test Farm, 1905-1910
Yields compared to those of its Parent Varieties and Zimmer Spanish

Pounds per acre

Year	Yield of Hybrid 200			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 200			
								Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection	Ohio Seedleaf	Little Graham	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1907	1,454	....	....	1,532	1,357	1,445	1,044	9	..	410	....
1908	1,271	1,191	1,350	1,372	1,235	1,304	950	—33	46	321	400
1909	1,339	958	1,597	1,445	1,209	1,327	930	12	270	409	667
1900	1,650	1,503	1,858	1,623	1,444	1,534	1,111	116	324	539	747
3-yr. av. 1908-1910	1,420	1,217	1,602	1,480	1,296	1,388	997	32	214	423	605

HYBRID 201

Hybrid 201 is a cross of Black Seedleaf and Cooley Hybrid, the latter being a cross of Connecticut Havana and Sumatra, originated in Connecticut by A. D. Shamel. This hybrid (201) in the first generation did fairly well, yielding 86 pounds per acre more than the average of its parents. In the second generation the progeny of the single seed plant used yielded 64 pounds less than the parental average and 180 pounds more than Zimmer Spanish. No gain in productiveness was made in the third generation grown in 1909, but one very fine, low growing plant with numerous large leaves was discovered among the still widely varying offspring. This one plant was saved and in 1910 its progeny produced 704 pounds per acre more tobacco than Zimmer Spanish and 442 pounds more than the average of the two parent varieties.

The quality of this strain of Hybrid 201 is very fine in many respects, but has a tendency to take on wrapper characteristics rather than those of filler types. Considerable variation still existed in 1910 and several selections were

chosen for testing in 1911. Two of these made a very promising growth and very good yields, although the data not being complete, they cannot be added to the table. One of these is a tall type with very numerous erect leaves and the other a low type with very long, drooping leaves with a smooth surface like Zimmer Spanish.

The yields from 1907 to 1910 are summarized in Table XXVI.

TABLE XXVI: Statistics of Hybrid 201, grown at Germantown Test Farm, 1907-1910 Yields compared to those of its Parent Varieties and Zimmer Spanish

Pounds per acre

Year	Yield of Hybrid 201			Average Yield of parent variety	Yield of Zimmer Spanish	Increased yield of Hybrid 201			
						Over average of parents		Over Zim. Spanish	
	Av. of all selections	Poorest selection	Best selection			Av. of all selections	Best selection	Av. of all selection	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1907	1,399	...	...	1,313	1,044	86	....	355	...
1908	1,130	1,130	1,130	1,194	950	—64	—64	180	180
1909	1,036	936	1,135	1,197	930	—161	—62	106	205
1910	1,815	1,815	1,815	1,373	1 111	442	442	704	704
3-yr. av. 1908-1910	1,327	1,294	1,360	1,255	997	72	108	330	363

HYBRID 204

Hybrid 204 is a cross of Black Seedleaf by Hybrid 83, the latter being a cross of Ohio Seedleaf by Hybrid 58, which in turn is a cross of Cuban by Connecticut Seedleaf. Hybrid 83 or rather the selection of it used in making Hybrid 204 was characterized by an exceedingly tall stalk with leaves large, drooping and very far apart. The quality was very poor and the tobacco was much subject to damage during curing and fermentation. Hybrid 204 seems to have escaped these defects of quality but has inherited the tall stalk of its parent, Hybrid 83.

TABLE XXVII: Statistics of Hybrid 204, grown at Germantown Test Farm, 1907-1910 Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 204			Average yield of parent variety	Yield of Zimmer Spanish	Increased yield of Hybrid 204			
						Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection			Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1907	1,338	...	...	1,227	1,044	111	...	294	...
1908	1,311	1,311	1,311	1,042	950	269	269	361	361
1909	1,131	1,014	1,376	1,057	930	74	319	201	446
1910	1,618	1,386	1,831	1,230	1,111	388	601	507	720
3-yr. av. 1908-1910	1,353	1,237	1,506	1,110	997	243	396	356	509

Hybrid 204 may be described as a very tall variety with an exceedingly hard' woody stalk and numerous dark green leaves which are semi-erect early in the season but later assume a horizontal position and finally become rather drooping. The quality of one selection in 1910 was very good both as to appearance and smoking quality when judged by smoking the cigars made from it after the tobacco was fermented. The parent form, however, in 1909 was of poor quality and it is still an open question whether the improvement was due to the selection of a more desirable variation or whether it was due to the difference in the seasons. If due to the latter cause a return of weather conditions like those prevailing in 1909 will again cause it to produce poor quality tobaccco. For yields see Table XXVII. See also, Fig. 30 page 464 for illustration.

HYBRIDS INTERMEDIATE BETWEEN SEEDLEAF AND SPANISH

All the principal hybrids of this group are half blood Zimmer Spanish, but the selections of them now being grown differ too much from that variety to permit classifying them with the Spanish type hybrids. The chief difference between the hybrids of this group and those of the Spanish group lies in the larger size of their leaves, and in the case of a few, in the general character of the cured tobacco. The four important members of this group are hybrids 77, 199, 110 and 170.

HYBRID 77

Hybrid 77 was originated in 1904 by cross fertilizing the blossoms of a plant of Hybrid 51 with Zimmer Spanish pollen, it is therefore half Zimmer, one fourth Cuban and one fourth Connection Seedleaf. The first generation of this hybrid produced about 200 pounds more than Zimmer Spanish and it dropped back about 100 pounds in the second year. In the third generation grown in 1907 there appeared a type with numerous large erect leaves which produced a very large yield of fine quality tobacco, having a very fine flavor and aroma. The cured product closely resembled Zimmer Spanish though the leaves were larger and relatively broader. Nearly all the selections now being grown have descended from this variation, and have retained much of the general appearance characteristic of this strain at that time though there have been a number of distinct strains developed.

Hybrid 77 has shown a steady gain in yield since the second generation culminating in 1910 with an average yield for all selections of 1504 pounds per acre or nearly 400 pounds more than the yield of Zimmer Spanish. In the same year the best selection produced 615 pounds more per acre than Zimmer Spanish and almost twice as much as the parental average. Some of the selections of this hybrid tend to produce rather thin leaves and would probably produce good wrappers in a wrapper district. A trial of this sort in the Medina County district during the season of 1910 resulted in a yield almost double that of Connecticut Havana.

Upon the whole, Hybrid 77 seems to have considerably greater drouth resistance than Zimmer Spanish. A study of the accompanying table will show smaller gains for the wet season of 1909 than for the dry years 1908 and 1910 while a comparison of the results in 1908 and 1910 show that hereditary improvement by selection was still taking place. Apparently there

is one selection that differs markedly from the rest in its moisture requirements, for it made a much larger yield in the wet year 1909 than in either of the dry seasons.

The smoking quality of all the selections of Hybrid 77 now being grown is very good and has a strong resemblance to Zimmer Spanish though some strains approach Cuban in flavor and aroma. The tobacco cures up very rapidly for such a heavy yielding, leafy sort and is not easily damaged during fermentation. The yields are shown in table XXVIII.

TABLE XXVIII: Statistics of Hybrid 77, grown at Germantown Test Farm, 1905-1910
Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 77			Yield of parent varieties				Yield of Zim. Span.	Increased yield of Hybrid 77			
									Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Cuban	Ct. Seedleaf	Zim. Span.	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1905	1,036	.....	.....	569	900	846	772	846	264	...	190	...
1906	1,297	1,288	1,306	598	1,187	1,206	997	1,206	300	309	91	100
1907	1,203	949	1,364	595	1,200	1,044	946	1,044	257	418	159	320
1908	1,224	1,062	1,333	553	806	950	770	950	454	563	274	383
1909	1,189	999	1,286	462	856	930	749	930	440	537	259	356
1910	1,504	1,352	1,726	633	1,027	1,111	924	1,111	580	802	393	615
3-yr. av. 1908-1910	1,306	1,138	1,448	549	896	997	814	997	492	634	309	451

HYBRID 109

This hybrid is a cross of Zimmer Spanish by Ohio Seedleaf and was produced in 1904. The first generation of this hybrid was a very large, leafy, rapid growing sort with large thin, semi-erect leaves having a very smooth surface resembling that of Zimmer Spanish. The second generation showed less tendency to break up than would be expected and produced a much better yield than in the third generation. This peculiar behavior brings up an interesting problem in genetics whose solution is not even hinted at by the data at hand.

TABLE XXIX: Statistics of Hybrid 109, grown at Germantown Test Farm, 1905-1910
Yields compared to those of its parent vareties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 109			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 109			
								Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Zim. Span.	Ohio Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1905	1,650	.....	.....	846	.....	.....	846	...	...	804	...
1906	1,535	1,242	1,730	1,206	1,607	1,407	1,206	128	323	329	524
1907	1,141	1,116	1,294	1,044	1,532	1,288	1,044	—147	6	97	250
1908	1,109	1,023	1,249	950	1,372	1,161	950	—52	88	159	299
1909	1,314	1,314	1,314	930	1,445	1,188	930	126	126	384	384
1910	1,535	1,535	1,535	1,111	1,623	1,367	1,111	168	168	424	424
3-yr. av. 1908-1910	1,319	1,291	1,366	997	1,480	1,239	997	80	127	322	369

Although there has been developed a good yielding strain of Hybrid 109 possessing fair smoking quality, upon the whole this hybrid has been disappointing in its behavior. As grown in the first generation it was one of the most desirable types ever grown at the Station but the best fixed selections derived from this cross will probably have to be discarded on account of the superior worth of other similar hybrids. For yields see Table XXIX.

HYBRID 110

Hybrid 110 is a cross of Zimmer Spanish by Cuban which is a surprising statement to be made about a hybrid belonging in this group and is rendered still more so when it becomes known that the reason for so placing it is because the leaves are too long to allow grouping it with the Spanish types. This hybrid was made in 1904 and the first generation yielded about on a par with Zimmer Spanish, the more productive parent. In habit of growth it was intermediate between the parent forms, the character of the stalk more closely resembling the Cuban and the leaves assuming an erect position more like Zimmer. Other leaf characters were more strictly intermediate between the parent forms.

Like all other hybrids having Cuban for one parent, Hybrid 110 showed an extreme amount of variation in the second generation and it has been found very hard to obtain fixed types from these. In fact, it was not until 1909 that any seed plants were obtained that have bred true to type. The yield obtained in in the second generation from a mixed lot of seed was above 150 pounds less than the first generation yield and 163 pounds less than that of Zimmer Spanish. Of the three selections grown in the third generation (1907) but one produced as much as the more productive parent, Zimmer Spanish, and all three were still very variable, scarcely two plants closely resembling each other. The quality was not good and was followed by very poor quality in the progeny of the only seed plant used in 1908. This poor quality is all the more remarkable in view of the fact, that the highest yielding of the two selections we are now growing, possesses extra fine quality, both apparent and real as determined by the smoking test. The best plant to be found in 1908 was used to perpetuate this hybrid the following year and for the first time the offspring showed that there was some prospect of obtaining a fixed type from this hybrid. There was still much variation but the range was much narrowed. This year there was also some improvement in quality. Two of the best plants as determined by the weight of the cured tobacco, the field habits and the smoking test, were used to continue the breeding of this now important hybrid.

Results in 1910 and 1911. The offspring of both the parent plants used in 1910 were remarkably uniform though there was considerable difference in type between the two selections. Both were very productive and both possessed good quality, though there was considerable difference in both respects. A very fortunate circumstance connected with this variation was the fact that the same selection excelled both in yield and in quality. The yield of this selection was 627 pounds per acre above that of Zimmer Spanish and just about double the average yield of the two parents. In habit of growth this high yielding type of Hybrid 110 is less erect than Zimmer Spanish but much less drooping than most varieties of Seedleaf. The leaves are close together and very long and somewhat narrower in proportion to their length than Zimmer leaves. The surface of the leaves is smooth like that of Zimmer Spanish and they cure up with the same fine, glossy finish, in fact, possessing these desirable qualities in still larger degree than does the Zimmer. The smoking quality is of the very best and in general resembles Zimmer Spanish.

This selection was grown by a few farmers in 1910 and the results indicate that it is well adapted to all kinds of soil and capable of making very heavy yields of good quality tobacco. In fact it seems to be capable, at least in dry seasons, of outyielding even the larger varieties of Seedleaf. The Smith Brothers, living five or six miles west of Germantown, grew a small amount of this sort and obtained a yield of 1,920 pounds per acre, under ordinary farm conditions, without heavy fertilization. This may be compared with a yield of 1,500 pounds per acre of Hybrid 81 in the same field, and when we consider that Hybrid 81 itself is capable of largely outyielding Zimmer Spanish, we can see the large possibilities of the new variety under consideration. Again in a cultural test conducted by the junior writer, Hybrid 110, upon heavily fertilized ground, yielded over 2,800 pounds per acre when suckered three times and allowed to stand four weeks after topping. These yields are very remarkable when we consider that this hybrid is but little later than Zimmer Spanish. This tobacco has greater tendency to wilt during hot, dry weather than most sorts but does not "fire" and is remarkably well adapted to such conditions. It also seems to be freer from liability to damage from shed burn and other curing house troubles than most varieties, and so far as we have any data the same seems to be true in regard to damage during fermentation.

Commercial outlook. From a commercial standpoint, Hybrid 110 has just one defect, it does not readily fall into any one of three long established classes of tobacco grown in the Miami Valley. Or, in the words of one of the tobacco warehousemen, "There are only three kinds of tobacco grown in this section, Dutch, Seedleaf and Spanish, and there is not much demand for any variety that cannot be thus classified." This condition of affairs in the tobacco trade is no doubt of great use in preventing too great multiplicity of types, but is a great drawback in the way of introducing really valuable new varieties which do not admit of being classified in the old way. The proper adjustment of these conditions to the satisfaction of the farmers on the one hand, and the merchants and manufacturers on the other, will involve time and study by both sides in the way of informing themselves as to the number and relative importance of various issues involved. If the manufacturer could be led to see the real merits of Hybrid 110, instead of appraising the quality by the nearness of approach to Zimmer Spanish in appearance, he would then be in position to put out a better cigar without increasing the cost.

A glance at the diagram, Fig. 24, will serve to show the very remarkable increase in yield that has been obtained since the second generation, and could the quality be represented in the same way the result would be still more startling. In considering this hybrid, it is well to remember that the only thing that keeps it from being considered one of the very finest Spanish varieties, is because the leaves are too long, a feature which we do not believe has any real disadvantages whatever; the discrimination against size having grown out of the habit of assuming that because the variety that has been arbitrarily set up as the standard of excellence, has small leaves and, therefore, length of leaf in itself is an indication of poor quality.

The yields of Hybrid 110 are summarized in Table XXX.

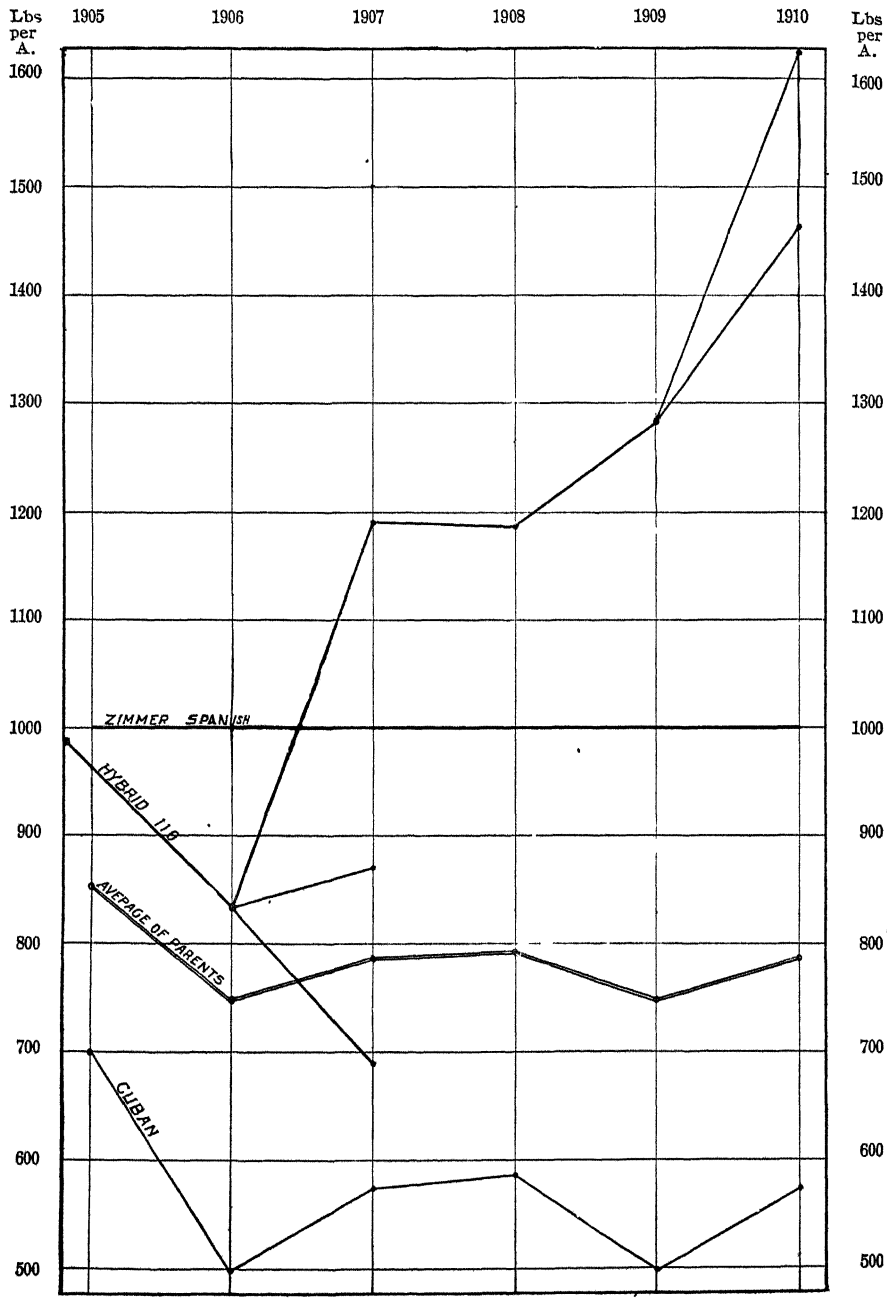


Fig. 24. Diagram showing yields and lines of descent in Hybrid 110 in comparison with the yields of the parent varieties; Cuban and Zimmer Spanish. Note the very large increase in yield during the later generations.

TABLE XXX. Statistics of Hybrid 110, grown at Germantown Test Farm, 1905-1910
Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 110			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 110			
								Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Zim. Span.	Cuban	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1905	836	....	....	846	596	721	846	115	..	—10	...
1906	1043	....	....	1206	598	902	1206	141	...	—163	...
1907	914	725	1235	1044	595	820	1044	94	415	—130	191
1908	1136	1136	1136	950	553	752	950	384	384	186	186
1909	1211	1211	1211	930	462	696	930	515	515	281	281
1910	1655	1572	1738	1111	633	872	1111	783	866	544	627
3-yr. av. 1908-1910	1334	1306	1362	997	549	773	997	561	589	337	365

HYBRID 170

Hybrid 170 is of the same parentage as 109, being the result of cross fertilizing a Zimmer Spanish plant with Ohio Seedleaf pollen in 1905. This was not nearly so promising in the first generation as was the similar hybrid, 109, already described, but has resulted in better permanent types. The large amount of variation in yield shown in the second generation was no doubt the result of the different conditions under which the various selections were grown. Nothing of real importance in this hybrid was developed until 1910, when the descendants of several of the parent plants were quite uniform, of desirable habit of growth and yielded well.

TABLE XXXI. Statistics of Hybrid 170, grown at Germantown Test Farm, 1906-1910
Yields compared to those of its parent varieties and Zimmer Spanish.

Pounds per acre

Year	Yield of Hybrid 170			Yield of parent varieties			Yield of Zim. Span.	Increased yield of Hybrid 170			
								Over average of parents		Over Zim. Span.	
	Av. of all selections	Poorest selection	Best selection	Zim. Span.	Ohio Seedleaf	Av.		Av. of all selections	Best selection	Av. of all selections	Best selection
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1906	1578	....	....	1206	1607	1407	1206	171	..	372	..
1907	1240	1068	1384	1044	1532	1288	1044	—48	96	196	340
1908	1085	985	1198	950	1372	1161	950	—76	37	135	248
1909	1135	1073	1231	930	1445	1188	930	—53	43	205	301
1910	1539	1441	1619	1111	1623	1367	1111	172	252	428	508
3-yr. av. 1908-1910	1253	1166	1349	997	1480	1239	997	14	110	256	352

The types selected to represent Hybrid 170 may be described as semi-erect, leafy, rather early tobaccos, whose leaves are smooth like those of the pistil parent, Zimmer Spanish, though after curing they bear some resemblance to Seedleaf. The leaves are long, relatively narrow and very close together on the

stalk. This variety cures up rapidly after being cut and altogether is very little later or more difficult to cure than Zimmer Spanish. From the field standpoint this is a very desirable type to grow.

Though the exact yields for 1911 have not yet been determined, this hybrid made a very desirable growth and a heavy production of good quality tobacco. Hybrid 170 has been given out in a very small way to a few growers who, for 1912, desire an early tobacco to take the place of Seedleaf. It is earlier than any of the old varieties of Seedleaf that are capable of approaching it in productiveness. The yields are given in Table XXXI.

LATER HYBRIDS

In addition to the four groups of hybrids already described there are a large number of promising ones of later origin. These are not yet fixed types but are still actively breaking up into numerous distinct types. Which of these hybrids will finally prove of value it is now impossible to state. Neither in most instances can the class to which will belong the selections of such hybrids finally retained be foretold. Many of these new hybrids are much more promising at the present time than were most of the older hybrids from which valuable fixed types have been obtained, at the same stage. A number of them, some for the second season, are under observation with a view of ascertaining their fitness for growing upon a commercial scale as first generation hybrids. From certain other ones it is hoped to develop valuable fixed types which shall prove even superior to the best fixed hybrids already obtained. Especial attention is called to the attempts being made to develop Spanish types approaching very closely to Zimmer Spanish in appearance and quality but having the ability to produce much heavier yields and to be freer from the other defects characteristic of that variety. We already have such varieties in Hybrids 81 and 224 but have hopes of attaining still greater excellence along this line with some of the later types under investigation.

POSSIBILITIES OF GROWING FIRST GENERATION HYBRIDS

At the meeting of the American Breeders' Association at Columbus, Ohio, February, 1911, the attention of the Association was called to this line of work through a paper entitled "Comparison of yields of first generation tobacco hybrids with those of parent plants," presented by the junior writer who some four years previous to that time first became convinced of the commercial possibilities of growing certain crops as first generation hybrids. Previous to that time the attention of tobacco men had been called to such possibilities in the winter of 1908 through a letter to the senior author, who at that time was attending a smoking test of the Ohio cigar filler tobaccos at Washington, D. C. As early as 1906 some experiments with corn were privately undertaken by the assistant botanist and the results up to the present time have shown decided and consistant gains in yield for first generation corn hybrids.

Fig. 26. First generation on Hybrid showing remarkable vigor: On left row of Hybrid 89, a fixed type; in the center Zimmer Spanish; on the right the large row is the first generation hybrid.

When the subject of growing first generation tobacco hybrids on a large scale was first broached to tobacco men, some expressed an apprehension, that the cost of producing the necessary hybrid seed would be a fatal drawback, but we are thoroughly satisfied that this is not a serious problem and should not on the average exceed 50 cents per acre. As already explained in preceding pages of this bulletin, accurate determination of the yields of first generation hybrids during the first few years' work at the Germantown Test Farm was not made, but their great vigor and productiveness were such as to suggest the advisability of obtaining such data in the future and also of determining the effects of cross fertilization within the limits of a fixed variety. For the latter purpose Zimmer Spanish was chosen. The average results from carefully worked out tests within this variety showed a gain of about 25 pounds per acre in favor of cross fertilization, an amount so small as to be well within the limits of error. It is probable that had a variety showing some variation, or to state it more accurately, a variety made up of a number of similar strains but differing somewhat among themselves been chosen, different results would have been obtained, probably a decided increase in yield in favor of the cross fertilized seed. As a matter of fact we do find that crosses between different plants

within the limits of certain more or less fixed selections of some of the hybrids have always resulted in a marked increase in yield in the first generation, this increase becoming greater as the relationship between the parent plants becomes more remote. These results are not altogether in harmony with the contention that line breeding is superior to narrow breeding, at least not for the first generation.

CROSSES BETWEEN DISTINCT VARIETIES—1908

Before going into the details of the experiments forming the basis of this discussion it should be stated that the opportunity was not present to make this line of investigation a major one. The hybrids were made primarily for another purpose but together with their parent plants were handled in such a way as to serve this purpose also. The results in yield and apparent quality have been such as to make one enthusiastic as to the possibilities of growing first generation hybrid tobacco as the main crop.

With this end in view a number of hybrids were made in 1907 in the following manner: Pairs of plants were selected and one-half the flowers of each were cross fertilized with pollen from the other member of the pair and the remainder allowed to self pollinate. This gave rise to four lots of seed from each pair, two from each plant, one of which arose from self and the other from cross fertilization. The four plantings for the next year's work consisted of each parent plant propagated through self fertilized seed and the reciprocal crosses of the two parent plants. The work was done in duplicate, making a total of eight plantings for each pair of parent plants. The results obtained in 1908 are shown graphically in Fig. 27 and embrace Hybrids 223-238; the columns of either side represent the average yield of the two parents and the cross hatched columns in the middle of each set show the average yields of the reciprocal crosses. It will be noted that in all cases the hybrids exceed in yield not only the average of their parents but also their more productive parents. The minimum increase per acre is 67 pounds while the maximum is 285 pounds per acre, the average being about 165 pounds. The result of reciprocal hybrids were so similar that under pressure of lack of ground for testing, subsequent crosses were made in but one direction.

RESULTS IN 1909

Thirty-nine new hybrids were tested this year, the yields of which together with those of their parent plants are in part shown in Fig. 27. The numbers of these hybrids run from 240 to 277. The parent plants of this group exhibited a much wider range in

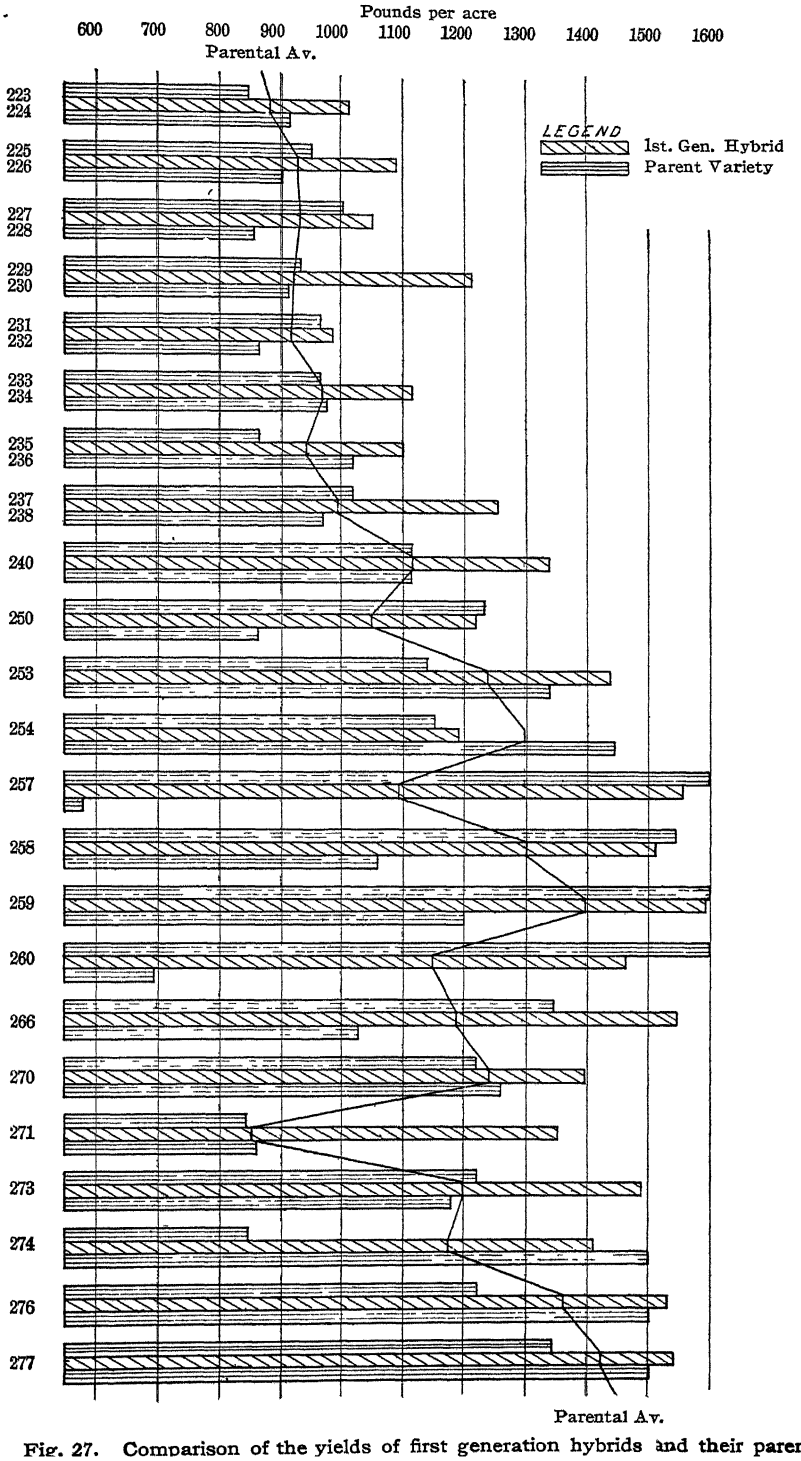


Fig. 27. Comparison of the yields of first generation hybrids and their parents.

yield both as to the two parents of a single hybrid and as to the group as a whole than was found to exist among the parents of the 1908 group. This year one parent of several of the hybrids was not grown because of evident inferiority at stripping time. In these cases its yield was assumed to be equal to the average yield of its sister plants. This, of course, was probably unfair to the first generation hybrid as such apparently inferior plants seldom yield as well as their better appearing sister plants. This possibly accounts for the failure of two of the hybrids to produce a yield equal to the parental average. None of the hybrids both of whose actual parent plants were grown in comparison with them, failed to produce a yield greater than the parental average. An inspection of Fig. 27 will show that these hybrids have in most cases produced considerably more than the parental average but that a number of them failed to reach the yield made by the more productive parent. The range of hybrid yields in 1909 as compared to that of their parents has for its minimum a decrease per acre of 160 pounds while the maximum has an increase of 492 pounds, the average of the hybrids is about 185 pounds greater per acre than that of their parent plants.

RELATION OF PARENTAL YIELD TO THAT OF HYBRIDS

The upper part of Fig. 28 represents the first generation hybrids grouped according to the average yield of their parents and shows both the average and maximum increase over their parents. The evidence is very strong that as the average yield of the parents becomes greater the excess yield of the hybrid over the parental average grows smaller. This is more conspicuous in the maximum than in the average increase. The hybrids in the lower section of Fig. 28 are grouped with respect to the difference in yield of their parents. The evidence here is not clear but from data from other sources it is thought likely that other things being equal large differences in the parental yields tend to augment the increase of the first generation hybrid over the parental average.

Notwithstanding the great gains shown by first generation hybrids over the parents we have in many instances been able in the third and later generations to produce yields much in excess even of the first generation. We have never yet produced a first generation yield equal to the combined yield of both parents, a feat which has been accomplished several times in later generations. It is an interesting fact that even after we have by selection pushed the yield beyond that of the first generation we can still further augment it by crossing these high yielding strains by others similarly obtained

even if they have been derived from the same original hybridization; the first generation of these intercrosses again yielding above their parents.

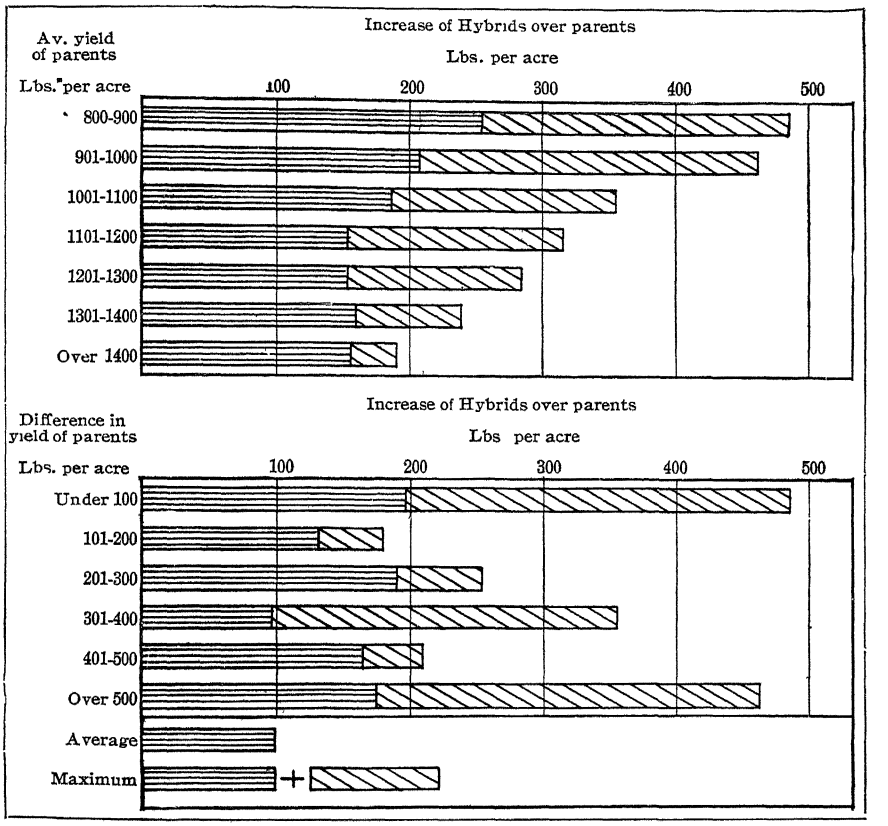


Fig. 28. Diagram showing the yield relation between first generations hybrids and their parents when the latter are grouped according to the average yield (upper section) and according to the difference in yields (lower section) of the two parents of each hybrid.

It will be interesting to see how far we can push this "see-saw" game of elevating yields by alternating hybridization with selection. As we advance the difficulties multiply. In the first place as the absolute yield of the first generation hybrid increases it becomes more and more difficult to surpass it in later ones. It would seem, or the evidence at hand would indicate, that as the foundation stock used for hybridizing becomes more highly developed we may expect the best fixed strains of hybrids which can be developed by practical means gradually to lose in relative yield until they fall below the yield of the first generation and finally below that of their parents. If this proves true then first generation hybrids offer the one chance of obtaining the highest possible yields.

COMMERCIAL OUTLOOK

We shall now turn to the commercial aspects of the matter. The questions most likely to arise in the grower's mind are "What will it cost to produce hybrid seed?" "Will the tobacco be uniform?" "Will the quality be equal to that of existing varieties?"

In answer to the first question we think the difficulties of perpetuating first generation tobacco hybrids can surely be no greater than those connected with the vegetative multiplication of fruit trees, which are first generation hybrids. Indeed, I believe the cost is much less than with trees which necessitate grafting. The number of seeds produced from a single flower is so enormous and the work of hybridizing so easy that the extra expense is insignificant in comparison with the increased yields which may be obtained. From my personal experience I think it can be conservatively stated that the added cost should not exceed 50 cents per acre.

It would not be necessary to produce seed each year, as tobacco seed retains its viability for a long time. Many farmers growing tobacco in the ordinary manner do not save seed oftener than once in three years.

In answer to the second question it may be said that first generation hybrids will not show essential difference in uniformity from the parent varieties. Indeed, if one or both parents are unfixed hybrids the first generation will be somewhat more uniform than such parents. Such parents, however, should be avoided and only fixed hybrids or straight varieties used when the end sought is the commercial usefulness of the first generation hybrids.

The matter of quality is not quite so easy of solution, but offers no diffculty not present in a new variety derived by other means. In general, it may be said that the various factors which go to make up quality will be more or less intermediate between those of the parents. This to a certain extent furnishes a guide in selecting foundation stock, but as in the matter of yield, the best combination can be finally determined only by trial. So far as quality is correlated with vigor of growth the hybrid is likely to excel the parents. In certain cases this is a factor not to be neglected, for it should be remembered that anything which increases yield, whether it be fertilization, cultivation, or inherent vigor, tends at the same time with certain exceptions to enhance quality.

The Station has several hybrids the first generations of which seem to possess a very desirable combination of quality and yield, but further testing will be done before offering them for distribution.

BREEDING FOR SPECIAL ADAPTATIONS

A study of certain strains of some of the hybrid varieties indicate that breeding for special adaptations is a promising line of investigation that should be taken up at once. Even though the strains having remarkable adaptations to certain environmental conditions should, through lack of excellence in other important characters, prove unfitted for general culture, they should still have great value for crossing with other varieties of general merit but lacking in the special adaptation under consideration. It seems entirely possible to produce new varieties with very greatly increased powers to with stand extremely dry weather, also types having much greater ability to make profitable use of the less available or more slowly available forms of plant food such as barnyard manure, other forms of organic matter and certain ingredients often found in commercial fertilizers. In facts such types already exist in hybrids 75 and 54. Other special adaptations seem equally possible of attainment, as for instance, the remarkable adaptability to continuous culture evinced by Hybrid 157.

The great value of the special adaptations above noted is obvious when coupled with other desirable characters. Severe droughts are of frequent occurrence in the Miami Valley and the use of varieties specially adapted to resist such weather conditions, in many seasons, could but result in greatly increased yields. On the other hand, the advantages of a tobacco especially adapted to continuous culture will at once appeal to the many growers so situated that it seems desirable to grow tobacco continuously on the same ground or at least for several years in succession. Again in the matter of its fertilizer requirements, tobacco, especially the Zimmer Spanish variety, is notoriously unable to make the best use of any but the most available forms of plant food. If a variety can be developed that will in this respect more nearly approach the capacities of other farm crops like corn and oats, the advantages are obvious. It is the intention to go into the details of but one line of breeding for special adaptations and that briefly.

BREEDING FOR DROUTH RESISTANCE

The experiments from which were collected the data shown in the accompanying diagram, Fig. 29 were not planned with this end in view, but a fortunate combination of weather conditions occurring during the three years, 1908-1910, has presented a very favorable opportunity for studying the moisture requirements, as related to the two extremes of rainfall, of the hybrids and standard varieties of tobacco under test at the Station farm. Of these three years,

1908 asd 1910 were very dry and 1909 extremely wet. It is not at all surprising that rather large differences in the moisture requirements should be found among the different varieties of tobacco. In seeking to discover with what other characters the adaptations to differing amounts of rainfall are correlated, one of the first probable relationships that occurs to the mind, is that heavy yielding varieties would require more and low yielding varieties less moisture for their best development. When we compare such large sorts as Ohio and Pennsylvania Seedleaf with the much lower yielding Zimmer Spanish and Cuban varieties, we find this hypothesis to hold true but when we bring Hybrid 75 into the list, this relationship is at once destroyed for though yielding but little less than the Seedleaf varieties, Hybrid 75 has by far, the smallest moisture requirements of the entire list. The extremely heavy rainfall in 1909 seems to have depressed the yield of this hybrid in about the same proportion that it augmented that of Pennsylvania Seedleaf. It should be further noted that the highest yielding selections from the various lines of descent show the adaptation to scanty rainfall in still more accentuated form than do the other selections of this hybrid.

The diagram in Fig. 29 shows the yields of two selections of Pennsylvania Seedleaf and four strains of Hybrid 75. (The word strain is here used to include all the descendants of a single mother plant of 1906). In some of these lines of descent there has been much variation and a wide range of yields as is indicated on the diagram by the dotted lines which show the yields of the best selections of two of the strains. These best selections show the ability to withstand dry weather to even greater degree than do their sister plants.

Whether or not the visible peculiarities of Hybrid 75 (for what these characters are see description of this hybrid, pages 419-424) are necessarily correlated with its lack of adaptability to wet seasons can not at present be determined for no other varieties have these characters. On the other hand it is quite certain that they are not necessarily correlated with its ability to withstand drouth for a selection of Hybrid 127 while contrasting with Hybrid 75 in nearly all its visible characters is fully as drouth resistant, but differs markedly from the latter in being equally well adapted to the opposite conditions and in its very prompt growth during the seedling stage and immediately after transplanting. It will be remembered that Hybrid 75 is very defective in its plant bed behavior and early growth after transplanting. In view of these facts it would seem possible to use Hybrid 75 to breed drouth resistance into new hybrids without the transmission of its undesirable qualities. In fact Hybrid 127 alluded to above is of such descent and is free from the defects

of its paternal ancestor, Hybrid 75, although the drouth resistant selection possesses other defects that will probably prevent its general culture.

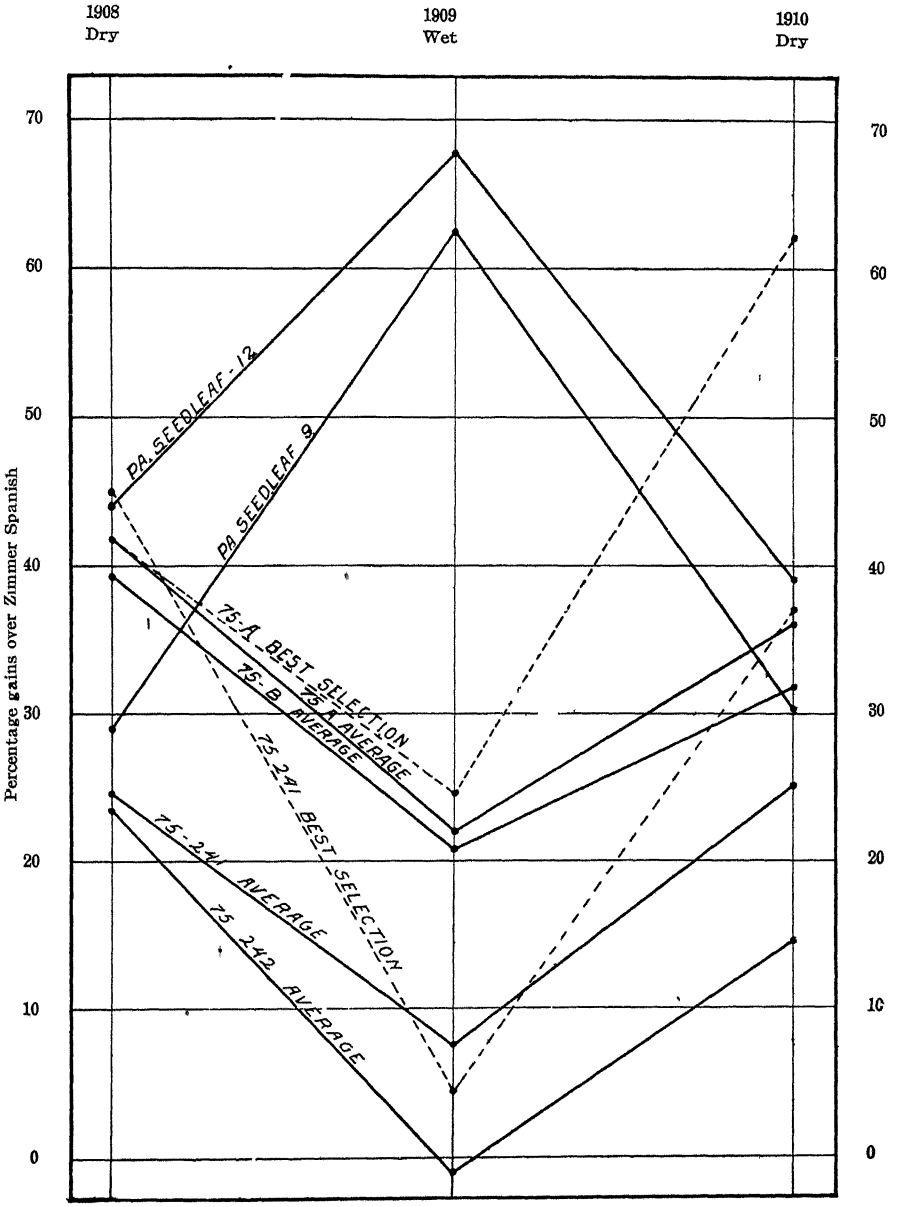


Fig. 29. Diagram showing contrasting effects of wet and dry seasons upon the yields of Pennsylvania Seedleaf and Hybrid 75.

COOPERATIVE TESTS BY FARMERS

Since the ultimate aim of the Germantown tobacco breeding work is to supply the growers of the Miami Valley and possibly other portions of the state with more profitable varieties of tobacco, some method of distributing seed of these improved varieties must be adopted. It has not been deemed wise by the Department of Botany to sell the seed or to give it to the growers with no restrictions as to its use. The plan followed has been to place seed in the hands of only those growers who are willing to give it an impartial test in comparison with some standard variety and report results to the Station and who sign a contract or agreement to this effect. This plan has the twofold advantage of giving the grower a much more accurate idea of the relative value of the new sorts he is testing in comparison with the standard varieties he has been accustomed to growing and on the other hand furnishes the Station with the data needed for studying the adaptability of the new hybrid varieties to the various conditions of soil and culture obtaining in the different parts of the tobacco growing district. In order to determine the smoking quality of hybrids as influenced by changes of environment and cultural treatment, the Station reserves the right at its option to purchase at the prevailing price for similar tobacco a small quantity of the resulting crop from those to whom it furnishes seed.

The aim in all cases is to make the cooperator as little extra trouble as is consistent with obtaining the desired data. After the first year growers who have tested one or more of the new varieties are at liberty to plant as large an acreage of these as they may desire and are under no restrictions as to the growing and disposition of such crops, but no seed is to be given to other growers without the permission of the Station.

Hybrid seed was first distributed in the spring of 1907 and consisted of several selections of Hybrids 72 and 75. These, though making good yields, did not give general satisfaction owing to their too great tendency to sucker production and because the tobacco did not readily fall into any of the established classes of tobacco. These points have already been discussed and here need only to be mentioned.

RESULTS IN 1909

The first important distribution of hybrid seed took place in 1909 when seed of Hybrids 54, 72, 75, 77, 86, 89 and 106 were given to some twenty growers in the vicinity of Germantown and at a few other points in the Miami Valley. In most cases but a small area was planted, most of the plantings ranging from 1-10 to 1-4 of an

acre, although some planted as much as two acres. Of the several selections of Hybrid 75 distributed, most of them yielded well although a few yielded less than Zimmer Spanish. The highest yield was obtained by the Baughman Brothers, of Ansonia, Darke county, Ohio. Their yields were as follows: Hybrid 75, 1,896 pounds per acre, Hybrid 54, 1,758 and Zimmer Spanish 1,407 pounds. The trash is not included in these yields. Hybrid 75 made an equally large gain over Zimmer Spanish for Mr. Aaron Sharritt, of Germantown, although his absolute yields were much smaller. As compared with Zimmer Spanish it produced for him 1,008 pounds of wrapper and filler against 528 pounds for the Zimmer. The total yields were 1,140 pounds for Hybrid 75 and 636 pounds for Zimmer Spanish. So far as cultivation and fertilization and the natural fertility of the soil were concerned, both were treated alike and the difference in yield must therefore be entirely due to hereditary differences of the two kinds of tobacco. Mr. J C. Chamberlain, of Carlisle, obtained yields as follows: Hybrid 72, 1,249 pounds per acre, Hybrid 75, 1,329, Hybrid 77, 1,714 and Hybrid 86, 2,108 pounds per acre. Mr. Chamberlain had no standard variety planted near for a check so no direct comparison of yields with those of old varieties is possible in this case but as compared with Seedleaf grown on other portions of the farm, Hybrids 77 and 86 made the larger yields. Hybrid 54 made a very good record as to yields but was not well liked owing to its tall stalk and late maturity. Hybrid 72 was not satisfactory either as to yield or field characters and its distribution ended with this year. Hybrids 77 and 86, both half blood Zimmers, made a very good record both as to yield and field behavior. Hybrid 89 yielded about 50 percent more than Zimmer Spanish and was satisfactory in other respects and is still being grown by some who first tried it. Hybrid 106 made very considerable gains over Zimmer Spanish, amounting to perhaps 35 percent of the yield of the latter. The cured tobacco of this sort closely resembles that of Zimmer Spanish and has given general satisfaction but will doubtless be displaced by such hybrids as 81 and 224, although a considerable acreage was still grown in 1911.

RESULTS IN 1910

In 1910 the same varieties were distributed as in 1909 with the exception of Hybrids 72 and 86; Hybrid 81 was added to the list. The results this year were very much the same for the hybrids already tested as were obtained the preceding year. Hybrid 81 which as above noted was given out for the first time this year, immediately found favor with many growers on account of its erect

habit of growth, hardiness and great ability to withstand severe windstorms without going down. In yield it made from 13 to 46 percent more than Zimmer Spanish under the same conditions. In general, buyers have been unable to distinguish the cured tobacco of Hybrid 81 from Zimmer Spanish, and in all cases tested, the smoking quality has been equal to that of Zimmer or better.

Fig. 30. Valuable recent discoveries. On left remarkable plant of Hybrid 257, mixed parentage, which developed 43 leaves before showing buds. On right remarkable plant of Hybrid 199 bearing 37 leaves; this was a chance variation selected among plants of lower form in the second generation, of a cross between Ohio Seedleaf and Big Graham.

RESULTS IN 1911

This year another Spanish type, Hybrid 224, and three Seedleaf types, Hybrids 179, 182 and 199, also one intermediate type, Hybrid 110, were added to the list for distribution. In 1911 there were about 90 cooperators and each one undertook to grow at least one-half acre of each kind taken. The yields and quality of the hybrids as grown by the various farmers who cooperated with the Station in testing out these new sorts in 1911 were such as to give great encouragement to the breeding work. The most popular hybrids in the Spanish group were numbers 81 and 224, while in the Seedleaf group Hybrid 199 easily takes first place. The demand for seed of these hybrid varieties for sowing in 1912 has been so great that the acreage that will be planted is limited only by the amount of seed available for distributiou. Hybrid 81 was grown by more farmers in 1911 than any other one hybrid and as an average of the whole acreage planted made a gain over Zimmer Spanish of considerably more than 300 pounds per acre. The highest yield was obtained by J. L. Flook, of Farmersville, for whom Hybrid 81 produced 1,991 pounds of wrapper and filler and a total of 2,240 pounds per acre against 1,154 and 1,278 pounds respectively for the wrapper and filler and the total of Zimmer Spanish. A very few growers through late planting or other adverse conditions had yields of this hybrid below those of Zimmer.

TABLE XXXII. Comparative yields of Hybrids 81 and Zimmer Spanish obtained by cooperative growers in 1911.

Name and address of grower	Hybrid or variety	Yield—Pounds per acre				Gain per acre over Zim. Span.			
						Wrapper and filler		Total	
		Wrapper	Filler	Trash	Total	Lbs.	Percent	Lbs	Percent
John Flook, Farmersville, O	Hybrid 81	1,652	339	249	2,240	837	72 5	962	75.3
	Zimmer	962	192	124	1,278				
Andy Argenbright, Germantown, O	Hybrid 81	1,323	151	251	1,725	267	22 1	267	18.3
	Zimmer	1,077	130	251	1,458				
J. Larkin Brouse, Eaton, O.	Hybrid 81	966	374	115	1,455	351	35 5	340	30.5
	Zimmer	696	293	126	1,115				
Adam Livingston Union City, Ind	Hybrid 81	1,500	291	27	1,818	511	39 9	506	38.5
	Zimmer	1,067	213	32	1,312				
Lewis Rice, West Milton, O	Hybrid 81	1,526	332	120	1,978	570	44 3	560	39 5
	Zimmer	1,023	265	130	1,418				
Average	Hybrid 81	1,394	297	152	1,843	507	42 8	527	40.4
	Zimmer	965	219	132	1,316				

In Table XXXII the results for 1911 of five representati ve growers of Hybrid 81 are given. In choosing these from the large number possible to have been included, care was taken to cover a wide range

of territory and soil conditions and to include only the reports of those growers who had conducted careful, accurate tests and who furnished complete data upon all required points. The average of the yields collected in this table are above the average for the whole list of growers but do not contain the results of all the tests where high yields were obtained. Among other farmers who obtained large gains over Zimmer Spanish may be mentioned Mr. Joseph Wiseman, of near Miamisburg, O., who, with the tall type of Hybrid 81, received a yield of nearly a ton to the acre or about 700 pounds more than the yield of Zimmer Spanish, and reported the quality good, the tobacco running very high in the wrapper grade. Also Mr. Robert Friend, of Waynesville, who reports a yield 800 pounds in excess of that of Zimmer and the quality good. In studying the yields presented in this table it should be remembered that we are dealing with a tobacco that is very similar to Zimmer Spanish and the comparisons should be made with that variety and not with Seedleaf, although in many cases Hybrid 81 would not suffer by such comparison.

TABLE XXXIII. Results of Cooperative Tests of Hybrid Tobaccos conducted by Aaron Sharritt on Farm 4 miles Northeast of Germantown

Hybrid or Variety	Yields—Pounds per acre				Gain per acre over Zimmer Spanish			
					Wrapper & Filler		Total	
	Wrapper	Filler	Trash	Total	Pounds	Percent	Pounds	Percent
1909								
75-A & B	1,008	*	132	1,140	480	90.9	504	79 2
75-3067	828	*	156	984	300	56.8	348	54.7
106-214	740	*	136	876	212	40.2	240	37.7
Zimmer	528	*	108	636	...	....	...	....
1910								
75-A & B	885	198	112	1,195	393	57.0	440	58.3
81-3040	840	168	87	1,095	318	46.1	340	45.0
Zimmer	575	115	65	755	...	....	...	....
1911								
224-105	968	136	144	1,248	272	32 7	336	36.9
110-3005	1,012	140	120	1,272	320	39 4	360	39.5
Zimmer	712	120	80	912	...	....	...	...

* Filler included with wrapper in 1909.

Before concluding our discussion of cooperative tests we wish to present in tabular form the results of one of our growers for the years 1909, 1910 and 1911 as showing the great advantages accruing from such tests both to the Station and to the individual who carries them out. These results were obtained by Mr. Aaron Sharritt of

near Germantown, who has been one of our most careful and trustworthy cooperators for several years and who is now growing his main crops from seed of Hybrid 81; he grows the much lower yielding Zimmer Spanish only as a check to measure the yields of other new varieties. These results are found in table XXXIII.

PROSPECTS FOR 1912

The total number of cooperative growers for 1912 is about 100 and the total acreage of hybrids to be grown in these tests amounts to something over 250 acres. It would have been much larger if seed could have been supplied to all who requested it. The greater portion of this acreage will be planted to Hybrids 81, 224 and 199. If to this we add the crops that will be grown by those who have previously conducted cooperative tests, the total acreage of hybrid tobaccos to be grown may be safely estimated to be somewhere between 500 and 1000 acres and possibly even more. If we assume an average increased production of 200 pounds per acre over the varieties they will replace, and this is a very low estimate in comparison with the actual increases that have been obtained by the cooperative growers, we find that from 100,000 to 200,000 pounds of tobacco will be added to the production of the Miami valley as the direct result of the seed distribution by the Experiment Station, a movement which has just begun. The introduction of these new varieties should also lead to improved yields from another source for they have greater capacity for profitably using large amounts of plant food and therefore respond more largely to heavy applications of fertilizers and to better care in general. It should be remembered that the relative yields of these new sorts as compared with the old varieties increase as the fertility of the soil and methods of culture are improved not only in their actual gains in pounds per acre over such varieties but even in their percentage gains.

HOW TO OBTAIN HYBRID TOBACCO SEED

Seed of such varieties as are deemed worthy of distribution by the Station can be secured when the supply is not exhausted by calling on or writing to True Houser, Assistant Botanist, Germantown, Ohio, who has charge of this work. Blank application cards and agreements will be given or sent as the case may be to applicants and upon their being properly filled out, signed and returned, the seed will be turned over to the applicants. Below are copies of the application card and agreement form used in the distribution of seed of the new hybrid tobaccos:

Tobacco Growers Card 1912.

Name.....Address.....

Name of farm.....

How reached .....

.....

Hybrid Tobacco Nos. taken:—

.....Will grow.....acre: Yield..... ..pounds

.....Will grow.....acre: Yield..... ..pounds

....Will grow.....acre: Yield.....pounds

Will also grow.....acres of.....

variety and compare these with.....

Ohio Agricultural Experiment Station

DEPARTMENT OF BOTANY

Tobacco Test Agreement 191....

This understanding of agreement between the Ohio Agricultural Experiment Station of Wooster, Ohio, and ....

of.....

covers their understanding as to growing a test of the following Germantown Hybrids in comparison with the standard varieties grown by said.....

.....

Hybrid Tobacco Nos. selected:—

.... Will grow.....acre: (Yield.....lbs.)

....Will grow..... .....acre: (Yield.....lbs.)

....Will grow.....acre: (Yield.....lbs.)

.....Will grow.....acre: (Yield.....lbs.)

The Experiment Station agrees to furnish sufficient seed of the hybrid number, or numbers above specified, to grow not less than one-half acre of the same and to visit and advise with respect to the crop: the said. .... agrees, in consideration of this seed supply, to grow at least one-half acre of the specified hybrid, or hybrids, giving to the crop from this seed supplied him the same fertilizers, cultivation and treatment given to his other crop of the standard variety named: (Underline the varieties grown, or, if not in the list, write them in the blank space). Zimmer Spanish, Closeleaf Spanish, Lauver Spanish, Ohio Seedleaf, Pennsylvania Seedleaf, Connecticut Seedleaf, Little Dutch or.....

and to harvest the same when in proper stage of ripeness, hanging each lot so as to be capable of separate handling; also to strip the same with his standard crop and to report the weights of cured leaf of the hybrid or hybrids, including trash, filler and wrapper grades in each.

He further agrees to sell to the representatives of the Experiment Station, such minor amount of the cured crop as may be needed for testing, at the prevailing price for similar tobacco.

Signed:

....

Representing the Ohio Agr. Expt. Station.

....

Grower.

Seed delivered as above specified. .....191.....

.....

Seed received, ...packet....., labeled as above..... .....191.....

.....

STANDARDS OF QUALITY IN OHIO GROWN FILLERS

Zimmer Spanish properly grown and handled has a leaf of reddish brown or chestnut color with a smooth glossy surface and is further characterized by moderate elasticity and considerable strength and toughness. This variety has come to be taken as the standard of excellence for cigar filler tobaccos in the Miami Valley. This way of judging tobacco takes into consideration the apparent quality alone and that only in an arbitrary manner, leaving the smoking or real quality out of consideration altogether. That the smoking quality can not be determined by the appearance of the tobacco has been abundantly proven by the smoking tests of hybrids and other tobaccos carried on by the Station.

In our opinion the time has arrived when less weight in judging tobacco should be given to its real or fancied resemblance to Zimmer Spanish. This is too much like trying to judge the laying qualities of fowls by the fancy points of their plumage. We are living in a practical age when with our domestic animals, performance records usually count for more than their looks, and we think the same principles should be applied in judging tobacco. It would certainly be to the advantage of all concerned if the trade should come to the view point where greater importance would be attached to the smoking quality of the cigars, whose filler is composed wholly or chiefly of Ohio grown tobacco, than to the appearance of this tobacco before it is made into cigars.

By this we do not mean that we should lose sight of certain factors other than smoking quality which are of importance in cigar filler tobaccos. Other qualities of importance are a high degree of immunity from black rot and other warehouse troubles and workability of the finished product. We must have a tobacco that will stand dipping well (at least so long as the, in many respects, crude method of case fermentation is in vogue) and go through the subsequent process of fermentation without damage. Workability of the finished tobacco is of importance as an aid in manufacturing. While tobacco that has been allowed to become over ripe makes an excellent smoke when once made into cigars, it offers on account of its lack of elasticity or bony condition, certain difficulties of manipulation not to be found in the same variety of tobacco cut at an earlier date. In cases like this the manufacturer is justified in offering more money for that cut earlier although the smoking quality of the two may be equal. Color and the finer points of texture are of great importance in wrapper tobaccos, but the great emphasis now laid upon these points in filler tobaccos does not rest upon a sound scientific basis and is of no more real importance so far as the worth of

the cigar is concerned than is the color of the soil that produced the tobacco. Within a variety, color may be some index of the smoking quality, but as between different varieties is of little importance in this connection. From this it should not be inferred that gross neglect and other extremely unfavorable conditions will not cause certain unfavorable results that will be manifested more or less independently of the variety, and are of importance in judging the crop; but it is urged that the minor varietal differences are of themselves of no diagnostic value in determining the smoking quality of tobaccos. They become of use only in identifying the variety whose real quality is known from experience. In view of these facts we claim that it is asking no favor, only justice, that our new hybrid varieties be judged by their behavior in the warehouse, the ease with which they can be worked and the quality of the cigars made from them and not by their resemblance or lack of resemblance to Zimmer Spanish.

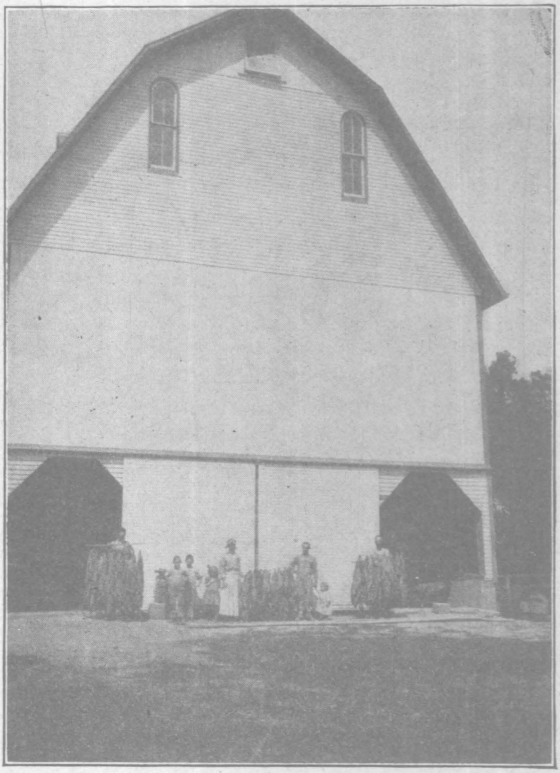


Fig. 31. Modern tobacco barn on farm of Baughman Bros., Arcanum, Ohio. This accommodates 9 tiers of large tobacco with vertical spaces between tiers of about 5 ft. each. Total height 47 ft.

GENERAL CONCLUSIONS AS TO HYRIDS TESTED

Many of the hybrid varieties have shown the ability greatly to outyield the old varieties of the classes to which they belong, and at the same time carefully conducted smoking tests have shown them to possess superior flavor and aroma; also fermentation tests have shown them to be comparatively free from black rot and other warehouse troubles. In field behavior they have the advantage of the old standard sorts, most of them being of erect, vigorous habit of growth and very resistant to windstorms, not much subject to rust and comparatively free from suckers.

In view of these facts, these new varieties should prove more profitable than the old ones now under cultivation. It is strongly urged that both the growers and other persons interested in the tobacco industry study these new types and inform themselves of their relative merits as compared with the standard varieties grown in the Miami Valley. Hybrids 81 and 224 of the Spanish types, Hybrid 199, a Seedleaf type, and Hybrid 110, which is intermediate in character, are especially recommended for trial.

FURTHER INVESTIGATIONS INDICATED

In addition to continuing the breeding out by selection of the hybrids already made, certain other lines of investigation are very strongly indicated. Among the most important of these are the following:

A campaign of education in order that growers, dealers and manufacturers may become better informed as to the real merits of the new hybrid varieties developed by the Experiment Station, and with a view, if possible, of putting the judging of tobacco upon a sounder and more scientific basis than the present one wherein such large value is attached to mere looks and this point itself, for the Spanish types, is judged very largely by the closeness of the resemblance to Zimmer Spanish.

The making of additional hybrids, especially crosses between the better ones already developed, with the hope of being able so far as possible, by subsequent selection to combine their good points, eliminate their bad ones and thereby produce new varieties that shall yield still more than the very productive hybrid varieties already developed and that shall be still freer from the suckering habit and other undesirable traits and that will still be more resistant to diseases and untoward weather conditions.

The development of productive types that will still more closely approach Zimmer Spanish in appearance than do such existing hybrids as 81 and 224, in order that, if the prejudice and ignorance

existing in the trade cannot be overcome, there may still be a means of supplying the farmers with more profitable varieties of tobacco that will completely meet the demand for a grade of leaf that at present can be supplied only by the low yielding Zimmer Spanish variety.

A continuance of the making and testing out of hybrids with a view to their possible usefulness for growing upon a commercial scale as first generation hybrids.

Breeding for special adaptations, such as drouth resistance, ability to utilize the less available forms of plant food, and adaptability to special types of soil, cultural methods, etc.

More careful study of types showing wrapper tendencies with a view to their improvement is indicated by the surprising results obtained in 1911 by Mr. J. E. Blohm, Special Agent of the Department of Agriculture, through harvesting the leaves of certain selections of Hybrids 75 and 277 by the "priming" method.

The continuance and application of the cultural experiments described in Bulletin 238 and their extension to all the important hybrid varieties. This is important in order to determine their special adaptations, the range of usefulness and the best methods of handling for each of these new varieties.

More careful and detailed study of the effects upon quality, of the various fertilizing materials, especially the different forms of potash as related to the burning qualities of tobacco after it is made into cigars.

SMOKING TESTS OF OHIO FILLER

The correct testing of the smoking quality of filler tobacco is not an easy matter when one seeks reliable results that may serve as standards for given sorts. These difficulties do not reduce the real need for such standards; the effort has been made in cooperation with the Office of Tobacco Investigations of the Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C., to work out methods and to conduct smoking tests.

The first smoking tests were made early in 1907 upon the breeding tobacco of the crop of 1906. The samples included those of the different varieties grown that year and the hybrids, especially from the different seed plants and were all sent as early as could be done for sweating and other preparations for the tests. We received the heartiest cooperation and assistance from every one connected with the work, and felt at the time, as we still do, that very profitable results, especially along the line of suggestions, were obtained by these first tests.

One of the first difficulties to be met was that of a score card which should both bring out the required factors and systematize the description and designation of the various factors into which the smoking quality may be divided. The score card* finally adopted, which appears below, was the result very largely of the suggestions of Mr. J. B. Stewart, at that time connected with the tobacco work of the Bureau of Plant Industry.

TOBACCO SCORE CARD—OHIO FILLER 1910

FLAVOR

Strength:
- Very strong
- Strong
- Medium
- Mild
- Light—Very light
- Flat

Quality or taste:
- Excellent
- Pleasant
- Good
- Fair
- Biting
- Disagreeable
- Bitter

AROMA

Fullness:
- Very full; very agreeable and cooling
- Full
- Smooth
- Fair
- Medium
- Defective

Foreign:
- Ill smelling
- Rank
- As of dried leaves

Resemblance:
- Cuban
- Seedleaf
- Zimmer
- Mixed
- Blend

* American Breeders' Association, 4.251-253, (1908).

TOBACCO SCORES—OHIO FILLER 1910

RECORD BLANK

No.	Hybrid No.	Smoking grade	Field grade	Flavor, grade Total (30 pts.)	Aroma, grade Total (50 pts.)	Burn (20 pts.)	Resemblance	Smoker
1								
2								
3								
4								
5								

As outlined in the blank form and record blank included, the grading was made upon a scale of 100 points distributed as follows: Flavor, 30 points; aroma, 50 points; burn, 20 points. In this work it was decided to use a uniform wrapper on the whole. With a wrapper of suitable quality it was found that the Ohio tobacco gave uniformly a satisfactory burn. This, perhaps properly, threw the differences in grades entirely under the heads of flavor and aroma. The descriptive sheet will indicate the segregation of the features of strength and quality under flavor, together with the descriptive terms used to indicate results; under aroma a similar separation into fullness, foreign qualities and resemblance was made with somewhat corresponding descriptive terms for the characters shown in the tests.

At the same time the smoking tests were made, Dr. W. W. Garner, of the Bureau of Plant Industry, made nicotine determinations of the remainder of the samples. Again in 1908 and in 1909 similar smoking tests were made from the previous year's crop, in cooperation with the Office of Tobacco Investigations of the Bureau. After Mr. Stewart's retirement from the Department, Mr. W. M. Hinson was in immediate charge of the tests, having the assistance of Mr. J. E. Blohm in this work. Dr. Garner again made the nicotine determinations on the small remnants in 1908 in the hope that some correlation might be established between the percentage of nicotine and the smoking qualities of tobacco.

NO APPARENT CONNECTION BETWEEN NICOTINE CONTENT AND SMOKING QUALITY

It was found, however, as the determinations multiplied that correlation of these matters of smoking quality and percentage of nicotine could not well be made. Consequently, the nicotine determinations were abandoned by Dr. Garner, and so far as I am aware, no publication has as yet been made on the large number of results secured. As with the nicotine results, so it proved impracticable with the smoking results to give detailed tables showing the outcome for each sort tested. However, enough has been learned to show the desirability and great value of these tests, by which we have been largely guided from year to year.

SMOKING TEST NOT AN EXCLUSIVE GUIDE

As is apparent from the discussions of the various hybrids in the preceding pages, the smoking test is not the only factor to be considered in the tobacco breeding work. In 1907 we were probably guided too largely by the results of the smoking tests. At this time not enough importance was given to the field behavior of the plants of the preceding season, of which the record is always kept, and of which illustrative examples are shown on page 386 of this bulletin. Anyone who goes over carefully the results obtained with the several hybrids, and given under their hybrid numbers in the earlier pages of the bulletin, cannot fail to be impressed with the very great importance of the field behavior and special characteristics of the plants in the growing crop. So that it has seemed better to reduce the matter and space given to the results of the smoking tests in this bulletin.

STANDARDS OF SMOKING QUALITY

The standards of cigar filler as developed in smoking are dependent on the characteristics of the various tobaccos grown in the several regions devoted to cigar tobacco. To illustrate, the imported grades of Havana, or as we call it, Cuban tobacco, are in high favor with most smokers, since these are of good flavor and have a high aroma—usually not being objectionable because of excessive strength or defective in the matter of aroma. For Ohio fillers our highest smoking grades are usually obtained from hybrids containing Cuban blood. The better selections of such hybrids seem fully equal in quality to pure Cuban as grown at Germantown, while they yield from two to four times as much. Most of these also contain Connecticut Seedleaf and many of them likewise Zimmer Spanish and one of them, Hybrid 110, is a combination of Cuban and Zimmer Spanish. Next in order come various combinations of several varieties including Ohio Seedleaf and Big Graham. Strange to say, some selections of a cross between the two latter varieties resemble Cuban in aroma. The Zimmer Spanish, on the other hand, while without objection from the standpoint of flavor, is somewhat deficient in aroma. We are forced to this conclusion by the consensus of opinion derived from the smoking tests. In very many cases the grades of the hybrid tobaccos on aroma are higher, and we might say, almost uniformly higher on those containing Cuban blood than those given to pure Zimmer Spanish. This statement is made as a general one so far as our breeding results go and is not designed in any way to reflect upon the possibilities of securing, as has been apparently secured from time to time from hybrid tobaccos, high aroma without Cuban ancestry.

RECENT SMOKING TESTS

The more recent smoking tests have not been made together as in the earlier tests at Washington, in which a great many experienced smokers were easily assembled to participate. Since the assignment of Mr. Blohm to Ohio for cooperation in the work, the fermentation of the tobacco has been carried on at Germantown, and the cigars subsequently manufactured and distributed for the tests. It has not been easy to secure uniform and complete reports from many of the cigars tested, so that we have only the incomplete data furnished in this way. It has been found, however, that the interest of tobacco men is fostered by these smoking tests, which they are invited to make for both themselves and our breeding work.

Since the construction of the building upon the Test Farm at Germantown, designed to accomodate the fermentation bulks of tobacco, as well as the earlier tobacco stripping, we will be in a position to conduct the sweating and preliminary preparation of the tobacco samples in larger bulks than heretofore, and, we might say, more nearly under like conditions to those prevailing in commercial leaf tobacco fermentation. Every indication points to the continuance of interesting results in the smoking tests for the hybrid tobaccos prepared and tested in this way.

ACKNOWLEDGMENTS

The authors wish to record their appreciation of the uniform liberality of the authorities of the Station in the support of the tobacco investigations and especially their obligations to Mr. Henry M. Wachter, superintendent of the Southwestern Test Farm at Germantown, Ohio, for his deep interest and great assistance.

They also wish to acknowledge their special obligations to the officers of the Bureau of Plant Industry, and especially to the members of the staff of the Office of Tobacco Investigations, who have at all times cordially supported and assisted in the work. The authors further beg to express their appreciation of the cooperation of so many growers who have joined in the testing of the new hybrids thus insuring their early growing in a commercial way.

ILLUSTRATIONS

The illustrations contained in this bulletin, Figures Nos. 1, 25 and 43 are from photographs by J. E. Blohm; the remaining figures are from photographs or drawings made by True Houser. The printing and preparation of pictures have been kindly done by the Station Gallery.

SUMMARY

This bulletin has been prepared to state the conditions surrounding tobacco improvement in the Ohio tobacco filler district, and to record the results of the efforts of the authors in producing new types of tobacco, both by selection and hybridization of previously known varieties.

The theory and practice of hybridization and tobacco breeding are discussed somewhat in detail, together with the resulting first generation fusion of characters and the second generation variation, pages 373-380.

The general methods of work consisting of selecting of seed plants, methods of bagging, labeling, individual plant records and system of planting in duplicate together with check rows, are set forth in considerable detail; pages 380-389.

An example of the individual plant record, including the usual form of record as to the size and number of leaves, the height of stalk, the length of internodes, the weight of cured leaves, etc., is given on page 386.

The selection work for the improvement of Zimmer Spanish, Seedleaf and Cuban is given in somewhat full detail with the diagram of comparative results; see pages 393-401.

The results from the breeding of the tobacco hybrids are given in detail in tabular form for the years 1908 to 1910 as compared with the results of Zimmer Spanish; see pages 402-405.

Table III, pages 407-408 contains an arrangement of these hybrids as grown, stated both in terms of the average of all selections, and of the best selection; yields given being those of the gain over Zimmer Spanish taken in pounds per acre.

A full list of the tobacco hybrids, showing the cross and parentage, and including 360 hybrids, is given on pages 409-414.

The hybrids of Cuban and Connecticut Seedleaf, including Nos. 54, 58, 69, 72 and 75, with detailed tables as to yields and increases of same over parent sorts are given on pages 415-425.

Especial attention is called to the diagram, figure 19, page 422, showing the ylelds and lines of descent of various selections of hybrid No. 75 in comparison with the yields of the parent varieties, Cuban and Connecticut Seedleaf.

Spanish type hybrids, namely, intercrosses between the hybrids previously described and Zimmer Spanish, including Nos, 81, 86, 106, 126, 127, 129, 157, 168, 224 and 238, are fully discussed on pages 425-439.

Attention is called to the diagrams showing parentage and lines of descent of the several selections of hybrid No. 81, compared with yields of the parent varieties, page 426. Also those of hybrid No. 89 shown on page 430.

Results with Seedleaf Hybrids, numbers 179, 182, 190, 199, 200, 201 and 204 are given with detailed tables of yields pages 439 to 446.

Hybrids intermediate between seedleaf and Zimmer Spanish including numbers 77, 109, 110 and 170 are discussed with tables of results pages 446-452.

The possibilities of growing crops of first generation tobacco hybrids are presented together with diagram of yields compared with those of their parent kinds, pages 452-459.

Breeding for special adaptions, including drouth resistance is discussed on pages 459-467 and diagram showing actual results obtained in years 1908, 1909 and 1910 is given on page 461.

The results of cooperative tests by farmers are set forth on pages 462-468. Especial attention is directed to Table XXXII which shows the heavy gains over Zimmer Spanish made by Hybrid 81 on the lands of farmers variously situated; also to Table XXXIII which gives the results for three years of a single cooperator in testing various hybrids in comparison with Zimmer Spanish.

For standards of quality note pages 468-470. Further investigations indicated are on pages 470-471. Smoking test results and special score card are presented on pages 473-474. For smoking grades as used in the individual plant record see table, page 386.

In conclusion the authors confidently invite attention to the results obtained through several years of effort and request tobacco growers to consider the advantages to be gained by growing the hybrids thus originated since they give largely increased yields of filler tobacco of superior quality.

For conditions under which seed of these new hybrids is given out consult pages 467-8 of this bulletin.

CHAS. E. THORNE, *Director, Ohio Agricultural Experiment Station:*

SIR:—This bulletin is the third in the series reporting upon the work of the Horticultural Department of the Ohio Agricultural Experiment Station in orchard rejuvenation in the southeastern part of the state. Nos. 217 and 224 describe the conditions prevailing in that section and deal with the results of spraying. This bulletin continues the discussion of the effects of lime and sulfur as compared with Bordeaux and shows clearly that the last named compound is not safe to use under the conditions described in the former bulletins.

Inasmuch as much thinning of apples had to be done the notes made at the time are here given, but one of the most important features of thinning, viz: the effect upon the trees in the production of the next crop, is yet to be determined.

The preservation of the trees against breaking by overloading and the effect upon future crops do not show in the tables, nor does the coloring of the fruit.

The need of fertilizing in many orchards in this section appears to be as great as that of spraying.

Unless both spraying and fertilizing are done profitable crops cannot be expected. The orchards operated upon are not isolated cases, but are typical of many others where long continued cultivation has used up the supply of humus.

The problems opened up, however, are not so easily solved as some seem to think. The work must take a wider range than the mere application of commercial fertilizers. The growing of cover crops, mulching and fertilizing will all need to be resorted to, separately or in combination.

That the work of orchard rejuvenation has already been taken up by the orchardists is shown by the fact that $200,000 worth of apples were produced last season in the territory where the crop previously has been almost nothing. There are good reasons for thinking that this is only the beginning of the good work.

Respectfully submitted,

W. J. GREEN, *Horticulturist.*

Approved:

CHAS. E. THORNE,

Director.